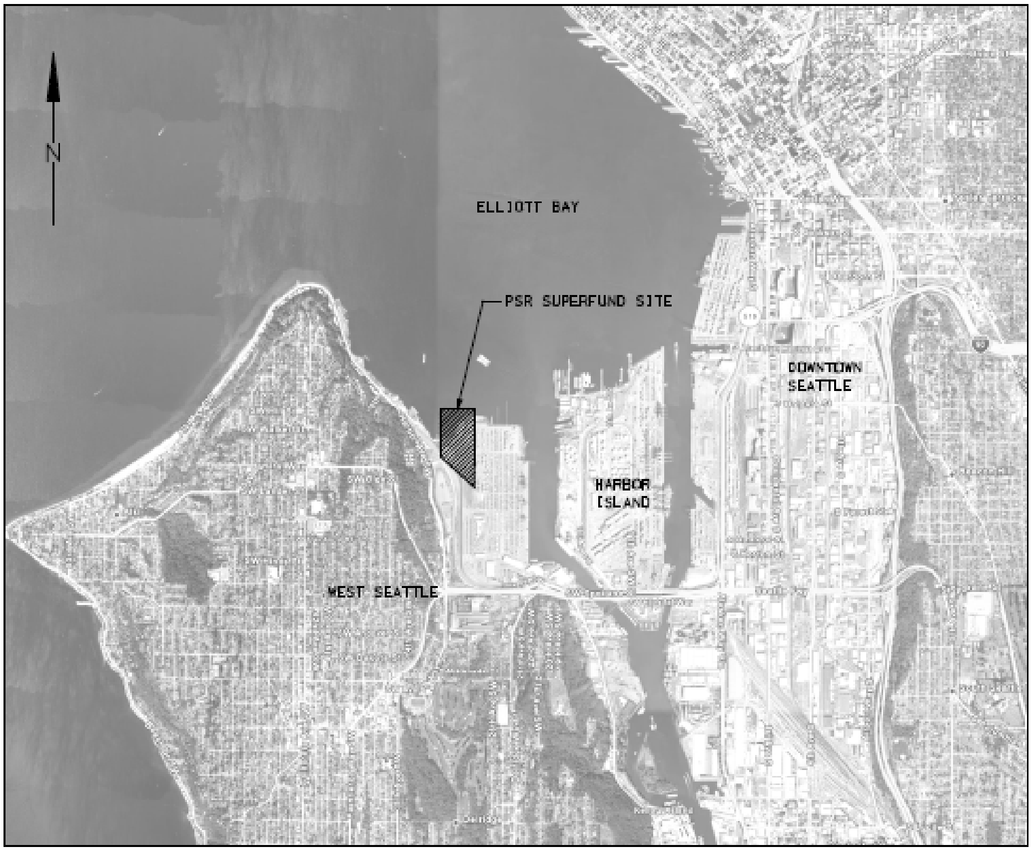
Five-Year Review Report
Pacific Sound Resources Superfund Site
Seattle, King County, Washington

First Five-Year Review for the Marine Sediments Unit
Second Five-Year Review for the Upland Unit



US Environmental Protection Agency, Region 10
Seattle, Washington

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Second Five-Year Review Report
for the
Pacific Sound Resources Superfund Site
City of Seattle
King County, Washington

September 28, 2009

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Region 10
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List of Acronyms and Abbreviations

ACL	Alternate Concentration Limit
AET	Apparent Effects Threshold
AOC	Administrative Order on Consent
ARAR	Applicable or Relevant and Appropriate Requirement
AWQC	Ambient Water Quality Criteria
bgs	Below ground surface
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CFR	Code of Federal Regulations
COC	Contaminant of Concern
cPAH	Carcinogenic Polycyclic Aromatic Hydrocarbon
CWA	Clean Water Act
CSL	Cleanup Screening Level
cy	Cubic Yards
DNAPL	Dense Non-Aqueous Phase Liquid
EPA	US Environmental Protection Agency
FS	Feasibility Study
FY	Fiscal Year
IC	Institutional Control
I&M	Inspection and Maintenance
ILCR	Incremental Lifetime Cancer Risks
IRIS	Integrated Risk Assessment Information System
LAET	Lowest Apparent Effects Threshold
2LAET	Second LAET
LNAPL	Light Non-Aqueous Phase Liquid
MCUL	Minimum Cleanup Level (Washington Sediment Management Standards)
MCL	Maximum Contaminant Levels
MCLG	Maximum Contaminant Level Goals
MLLW	Mean Lower Low Water
MSU	Marine Sediments Unit
MTCA	State of Washington Model Toxics Control Act
MW	Monitoring Well
NAPL	Non-Aqueous Phase Liquid
NCP	National Contingency Plan
NMFS	National Marine Fisheries Service
NTCRA	Non-Time Critical Removal Actions
OM&M	Operation Maintenance & Monitoring
OC	Organic Carbon Normalized
OSA	Outside Site Area
OU	Operable Unit
PAH	Polycyclic Aromatic Hydrocarbons
PCB	Polychlorinated Biphenyls
PCOR	Preliminary Closeout Report
PCP	Pentachlorophenol
PPA	Prospective Purchaser Agreement
PSR	Pacific Sound Resources Superfund Site
RA	Remedial Action Area (in Marine Sediments Unit)
RAO	Remedial Action Objective

List of Acronyms and Abbreviations (continued)

RCRA	Resource Conservation and Recovery Act
RD	Remedial Design
RfD	Reference Dose
RI	Remedial Investigation
RME	Reasonable Maximum Exposure
ROD	Record of Decision
RPM	Remedial Project Manager
SWDA	Safe Drinking Water Act
SMS	Sediment Management Standards
SPME	Solid-Phase Microextraction (device)
SQS	Sediment Quality Standard (Washington Sediment Management Standards)
TBC	To Be Considered
TCDD	Tetrachlorodibenzo-*p*-dioxin
TEF	Toxicity Equivalence Factors
TEQ	Toxicity Equivalence
TI	Technical Impractability
US	United States
USACE	United States Army Corps of Engineers
USCG	United States Coast Guard
UU	Upland Unit
WAC	Washington Administrative Code
WQS	Water Quality Standards

Executive Summary

The US Environmental Protection Agency (EPA) Region 10 Office of Environmental Cleanup has completed the second Five-Year Review of the Pacific Sound Resources (PSR) Superfund Site in Seattle, Washington. The purpose of this review is to determine whether the remedial actions implemented at PSR are protective of human health and the environment. This Five-Year Review is required because soil, sediment, and groundwater remedial actions have left hazardous substances on-site above levels that allow for unrestricted use and unlimited exposure. The methods, findings, and conclusions of the review are documented in this report. In addition, this report summarizes issues identified during the review and includes recommendations and follow-up actions to address them. This second Five-Year Review was conducted five years subsequent to the first Five-Year Review, which was completed in September, 2004. The first Five-Year Review covered only the Upland Unit because the Marine Sediments Unit cap remedy had not been completed at that time. This is the first comprehensive Five-Year Review covering both operable units. This Five-Year Review compares available groundwater and sediments contaminants of concern (COC) chemistry data to potentially relevant and appropriate drinking water standards, applicable State of Washington Sediment Management Standards, and, for information only (since they exist), to Alternate Concentration Limits (ACLs).

PSR is a former wood treating facility located adjacent to Elliott Bay on Terminal 5 in West Seattle, Washington (Figure 1). Wood was treated at the Site from 1909 to 1994 using preservative chemicals including creosote, pentachlorophenol (PCP), and metals. Soil, groundwater and marine sediments were impacted by these operations and non-aqueous phase liquids (NAPL) remain present in the Site subsurface. PSR is separated into two operable units: the Marine Sediments Unit (MSU) and the Upland Unit (UU).

Upland Unit

The UU comprises 25 acres. The primary sources of contamination to the UU are associated with the former treating areas, discharge pits, equipment, tanks, and loading areas. The Record of Decision (ROD) selected source removal and site stabilization actions to eliminate accessible, near-surface wood-treating chemicals and process residuals in the upland. The Early Actions completed at the time of the ROD were selected as part of the final remedy for the Upland Unit. These included: (a) demolition of all on-site structures, (b) near surface highly contaminated soil and sludge removal, (c) relatively small quantities (as compared to total volume) of NAPL collection and disposal, (d) isolation of remaining contaminated soil and groundwater from upland receptors with a low-permeability asphalt surface cap, and (e) a subsurface slurry wall to eliminate surface water sheens and potential beach staining, and to impede migration of contaminated groundwater at higher elevations. In addition, the final remedy included an Inspection and Maintenance (I&M) program for the Upland Unit surface cap, ongoing monitoring of groundwater, ongoing passive collection of NAPL, and Institutional Controls (IC) prohibiting groundwater use and restricting land use.

A primary source of groundwater contamination was eliminated through excavation and disposal of approximately 3,840 tons (approximately 2,400 cubic yards) of process residual materials present in shallow Site soils. Soil, groundwater, and marine sediments have residual NAPL

consisting of types that are lighter than water (LNAPL) and float in the water table, and types that are denser than groundwater (DNAPL) and sink below ground surface. According to the ROD, the volume of LNAPL at PSR is small relative to DNAPL. As an Early Action, a low permeability asphalt cap (4 to 8 inches) was placed in the upland area of PSR to reduce groundwater recharge and the potential for contaminants to migrate from unsaturated soil to groundwater via stormwater infiltration. A "hanging" bentonite slurry containment wall was installed in 1996, 40 feet below ground surface (bgs), to contain shallow contaminated groundwater and LNAPL flow to Elliot Bay. An LNAPL collection trench was installed on the upland side of the slurry wall to capture seeps that had been observed along adjacent Elliott Bay prior to Early Actions. Note that flow beneath the hanging wall as mobile product or groundwater "stringers" was not controlled by this remedy. The 1999 ROD selected these Early Actions as the final remedy for the UU.

Secondary sources remaining on-site consist of contaminated soils and groundwater with creosote- and chlorinated phenol-derived contamination. Significant uncertainties remain regarding the extent of DNAPL veins or stringers in the subsurface, and the extent to which they affect adjacent media (groundwater and surface water). The ROD states that approximately 53,000 gallons of free-phase DNAPL remain in the shallow, intermediate, and deep subsurface zones on-site; of this, approximately one-fifth, or 10,000 gallons, remains seaward of the slurry wall beneath the land and sediment surface. DNAPL occurs in sand lenses for a significant distance beneath, and within an estimated 200 horizontal feet of the top of the Elliott Bay mud-line. The ROD's conceptual Site model was based upon few borings, and the spatial extent of DNAPL is uncertain. No wells were completed below the affected aquifers at the Site; thus, it is unknown whether the formation that occurs under the deeper Site aquifer (Zone B, Figure 5) is an aquitard that prevents downward migration of groundwater.

The potential for secondary sources to discharge contamination into Elliott Bay was evaluated in the ROD using Alternate Concentration Limits (ACLs) as groundwater cleanup criteria. At the time, Section 121(d)(2)(B)(ii) of the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) authorizing ACLs in specified limited circumstances was expansively misinterpreted in the existing EPA guidance (i.e., the use of ACLs was fundamentally misunderstood nationally). The ACLs in the ROD were calculated groundwater concentrations that were predicted to allow surface water to meet ambient water quality criteria and sediment quality criteria over a long period of groundwater discharge to Elliott Bay. The ROD established these ACLs as remedial action goals with shoreline monitoring wells as alternate points of compliance. Specifically, ACLs were improperly used as a substitute for groundwater Applicable or Relevant and Appropriate Requirements (ARARs), and then misunderstood with respect to resulting surface water quality as follows:

1. ACLs were used in lieu of Applicable or Relevant and Appropriate Requirements (ARARs), specifically Safe Drinking Water Act (SWDA) Maximum Contaminant Levels (MCLs), required by Section 121(d)(2)(A)(ii) of CERCLA for potable water.

2. ACLs were calculated merely to meet ambient water quality criteria under Sections 303 and 304 of the Clean Water Act, (an overarching surface water ARAR pursuant to Section 121(d)(2)(A)(ii) and (B)(1) of CERCLA) rather than to ensure the more stringent "no

statistically significant increase" of groundwater constituents in surface water required for properly calculated ACLs by Section 121(d)(2)(B)(ii)(II).

As explained in more detail in Section 4.1.3, ACLs were impermissibly selected in lieu of MCLs and in any case misapplied with respect to surface water in the ROD. Since the use of ACLs set the pattern for data collection during monitoring, critical data do not currently exist for transition zone and shallow surface water quality. In addition, transition zone water data is needed for the near-shore sediment cap in the area of the estimated DNAPL extension into Elliott Bay.

In addition, the UU and MSU remedies did not adequately address the uncertainties related to the migration of DNAPL below the Site. Uncontrolled, potentially-migrating DNAPL stringers may have released, or be presently releasing, contamination into Elliott Bay as non-aqueous phase product or upwelling dissolved phase contaminants from groundwater. Without more information regarding the DNAPL stringers, it is not possible to determine the extent to which these stringers pose current or potential risk. Specifically additional data is needed to determine whether surface water and sediment in the near-shore area are protected from remaining DNAPL that currently exists outside the slurry wall or which may migrate below the wall in the future.

Other significant issues noted for the UU during this review include:

- Despite their inappropriate leniency as performance standards, (the PSR ACLs are much less stringent than acceptable criteria) there are numerous PSR ACL exceedances for PCP, dibenzofuran and several polynuclear aromatic hydrocarbons (PAHs) in shoreline wells designated as alternate points of compliance.

- The Washington Model Toxics Control Act (MTCA) Method C groundwater cleanup standards (ARARs) for benzo[a]pyrene, carcinogenic PAHs, total naphthalenes, fluorene, PCP, and dibenzofuran have been exceeded in shallow and intermediate groundwater wells outside the slurry wall.

- Although no surface water samples or near-shore sediment samples have been collected recently, information on increasing groundwater contaminant concentration trends and increasingly DNAPL-impacted shoreline sentinel wells indicate that contamination could be migrating shoreward (USACE 2009).

- During the site inspection, it was noted that a maintenance building should be evaluated for soil-vapor intrusion based on the known groundwater contaminant levels. This building was not present at the time of the remedy or the last Five-Year Review.

Several recommendations from the first Five-Year Review still require implementation. Additionally, routine scheduled maintenance of the asphalt cap, including repair of faded wellhead protection markings and worn asphalt sealant, and monitoring well maintenance are needed.

Marine Sediments Unit

The MSU is an approximately 58-acre area that includes approximately 1,500 linear feet of shoreline, and intertidal and subtidal areas to a depth of approximately 300 feet. Remedial actions in the MSU included dredging of approximately 10,000 cubic yards of contaminated sediment (to maintain post-cap navigation depth), placement of an engineered sediment cap, vegetative plantings on the shoreline, ongoing monitoring of cap thickness and stability, surface sediment chemical concentrations and biological conditions, and ICs to prevent use of large anchors on the cap area.

Based upon available chemical, biological, and physical data, the cap appears to provide uncontaminated marine habitat over the majority of the remediated area consistent with the Sediment Management Standards, the ROD's stated chemical and biological criteria. However, there is a lack of recent near-shore sediment chemistry data, due to an inability to sample the cobble/rip-rap intertidal area. Surface-weighted area concentrations meet the Sediment Quality Standards (SQS) of the SMS, and two of three biological tests confirmed that compliance with SMS was achieved. Physical monitoring of the shoreline and near-shore capped areas indicates no significant changes in the capped area.. However, monitoring has repeatedly demonstrated that the sediment cap in the deep remedial action area of the MSU (RA5) has not been fully constructed to meet the cap thickness design specification, and further placement of cap material is necessary.

Protectiveness Statements

The remedy implemented for the Upland Unit has eliminated current human exposure; however, DNAPL in the saturated zone has not been fully characterized or remediated, and DNAPL and dissolved NAPL contaminants have been detected in several near-shore monitoring wells. A protectiveness determination of the remedy related to migration of contaminants from the Upland Unit cannot be made until further information is obtained. Further information will be obtained to support administrative determinations, as described in the Superfund Environmental Indicators section below.

The sediment cap monitoring has indicated that the MSU remedy currently meets performance criteria, based on general attainment of the chemical and biological SMS within the stated scope of the MSU Operations and Maintenance (O&M) Monitoring Program. However a protectiveness determination for the remedy at the MSU cannot be made until further information is obtained, as described below, which will assist administrative determinations described below.

A protectiveness determination for the overall remedy at the PSR Superfund Site cannot be made until further information is obtained, as recommended in Section 9, Recommendations and Follow-Up Actions. Further information will be obtained by: (a) collecting UU groundwater, MSU sediment and surface or pore water data, (b) updating the conceptual Site model, and (c) re-evaluating ARARs, cleanup levels, and points of compliance. It is expected that these actions will take up to four years to complete, at which time a protectiveness determination will be made. It is likely that some uncertainties will always remain regarding subsurface DNAPL location and potential for discharge into sediments and surface water.

Superfund Environmental Indicators

The Human Exposure Environmental Indicator Status for the Site remains "Under Control." No one is using contaminated groundwater at the Site, and terrestrial exposures that posed unacceptable risk to human health were addressed by the removal and/or capping of contaminated structures, soil, and sediment. To ensure that this indicator remains "Under Control" for the long term, the follow-up actions recommended in this review need to be completed.

The Groundwater Migration Environmental Indicator Status for the Site remains "Not Controlled." Contaminated groundwater may be continuing to migrate from the Site. Completion of the follow-up actions recommended in this review should provide sufficient information to determine the significance of the uncontrolled contamination and help determine options to address the problem.

Cross Program Revitalization Measure Status. The Site continues to be "protective for people under current conditions." To ensure the Site remains protective, the follow-up actions recommended in this review need to be completed.

Five-Year Review Summary Form

SITE IDENTIFICATION		
Site name ***(from WasteLAN)*****: Pacific Sound Resources**		
EPA ID ***(from WasteLAN)*****: WAD009248287**		
Region: 10	**State: WA**	**City/County: Seattle/King**
SITE STATUS		
NPL status: ☒Final ☐Deleted ☐Other (specify)		
Remediation status (choose all that apply): ☐Under Construction ☐Operating ☒Complete		
Multiple OUs?* ☒YES ☐NO	**Construction completion date:** 2005	
Has site been put into reuse? ☒YES ☐NO Port of Seattle container terminal, Public park		
REVIEW STATUS		
Lead agency: ☒ EPA ☐State ☐Tribe ☐Other Federal Agency ____________________		
Author name: Ravi Sanga		
Author title: Remedial Project Manager	**Author affiliation: USEPA Region 10**	
Review period: November 18, 2008 to September 15, 2009		
Date(s) of site inspection: November 19, 2008		
Type of review: ☒Post-SARA ☐Pre-SARA ☐ NPL-Removal only ☐Non-NPL Remedial Action Site ☐ NPL State/Tribe-lead ☐Regional Discretion		
Review number: ☐ 1 (first) ☒ 2 (second) ☐3 (third) ☐Other (specify) __________		
Triggering action: ☐Actual RA Onsite Construction at OU # 02 ☐Actual RA Start at OU#____ ☐Construction Completion ☒Previous Five-Year Review Report ☐Other (specify)		
Triggering action date ***(from WasteLAN)*****:** September 2004		
Due date ***(five years after triggering action date)*****:** September 2009		

Notes:
* "OU" refers to operable unit.
Review period should correspond to the actual start and end dates of the Five-Year Review in WasteLAN.

Five-Year Review Summary Form, continued

Significant issues identified during this Five-Year Review that need to be addressed to make a protectiveness determination and contribute to long-term protectiveness of the remedy:

1) Groundwater and marine surface water compliance. The ROD's ACLs are not appropriate standards to demonstrate compliance and protectiveness; nonetheless, even the very lenient ACLs have been exceeded in several wells. The use of ACLs and the related assumptions were flawed (see Section 4.1.3) and the cleanup levels based on them are not protective of the environment (surface water quality or aquatic organisms) when compared to likely ARARs. Potential surface water ARARs are identified in Table 6 of Section 7.1.2.

2) Increasing concentrations of dissolved contaminants and newly DNAPL-contaminated or increasingly DNAPL-contaminated wells suggest possible migration seaward. However, there are no surface water quality monitoring data to assist in determining whether the UU remedy is protective of this medium. DNAPL characterization beneath the UU and MSU is incomplete or inadequate. Additional investigations and monitoring are needed to better define COC sources, extent, depths and architecture, fate and transport. In light of this, it is not possible to determine either current or long-term protectiveness.

3) There is a lack of sediment sampling in the near-shore area of RA1, RA2a and RA3 to verify that uncontrolled contaminants are not reaching sediments at unacceptable concentrations.

4) Incomplete construction of the isolation cap in RA5.

5) A key MSU Institutional Control (US Coast Guard restriction on anchorage) for protecting the cap has not been implemented.

6) Groundwater potability was not adequately evaluated in the upper or lower aquifers, although the ROD states that prospective future water supplies (potable water) are present in at least part of the Site. Groundwater potability at the Site must be determined throughout the Site to determine whether and where drinking water standards (ARARs) should be met.

7) Potential vapor intrusion into the maintenance building above the UU cap was not evaluated.

Five-Year Review Summary Form, continued

Recommendations for follow-up actions for issues (from previous page) that need to be completed to make a protectiveness determination and contribute to long-term protectiveness of the remedy:

1) Re-evaluate ARARs, cleanup levels, and points of compliance. Assess practicability of achieving ARARs, Remedial Action Objectives AOs , cleanup levels, and waiver potential for any ARAR that can't be met. Make revisions, including elimination of ACLs, in a ROD Amendment.

2) a) Additional DNAPL Characterization to better define contaminant sources, volume (or mass), extent, depths, and the extent of flow paths using optical screening tools with push probe insertion, e.g., TarGOST; also measure upwelling flux rates, direct-push fluorimetry, etc.

b) Collection of near-shore sediment, groundwater, surface or pore water data in the transition zone to evaluate discharge of contaminated groundwater or NAPL.

c) Additional data collection of sediment and pore water on near-shore cap areas (RA1, RA2a, and RA2b) for suspected subsurface DNAPL. (RA4 is not amenable, due to rocky cap materials.) Sample media to 55 feet below Mean Lower Low Water (MLLW) in the vicinity of the northern point of the UU coastline for sediment and pore water. For the latter, use a field-deployable Solid-Phase Microextraction (SPME) push-point device that is capable of measuring vertical profiles of freely dissolved hydrophobic contaminants. Additionally, near-surface pore water sampling for pentachlorophenol is also needed because this compound does not adsorb to the SPME. Sample locations are shown on Figure 13. Dissolved phase pore water concentrations may be used to infer the proximity of a DNAPL source and reveal whether dissolved phase DNAPL contaminants could infiltrate the sediment cap.

d) Update Conceptual Site Models with the new information and additional study results.

3) See Recommendation 2c above as regards sediment sampling.

4) Add suitable material to the RA5 cap to increase thickness as clean, dredged materials become available.

5) Implement remaining ROD ICs by working with US Coast Guard to establish anchorage restrictions to protect MSU Area 6 cap.

6) Potability Determination

a) Based on existing data and new data as necessary, determine: (i) whether the formation underlying the contaminated Site aquifer is a confining layer; (ii) the potability of groundwater underlying the confining layer beneath this formation; and (iii) whether the upper aquifer is potable under any portion of the Site.

b) If groundwater is potable, drinking water requirements are relevant and appropriate.

7) Groundwater/soil NAPL to indoor-air assessment for maintenance building with either groundwater data from adjacent wells/piezometers, or near-slab subsurface data.

Five-Year Review Summary Form, continued

Current and Long-term Protectiveness Statement

Upland Unit and Groundwater Transition Zone

The remedy implemented for the Upland Operable Unit has eliminated current human and ecological terrestrial exposure to site COCs; however, subsurface DNAPL is not fully characterized or remediated, and DNAPL and dissolved contaminants are present in near-shore monitoring wells and may be continuing to move into these wells and beyond. A protectiveness determination of the remedy related to migration of contaminants from the Upland Unit cannot be made until further information is obtained, as recommended in Section 9, Recommendations and Follow-Up Actions. Further information will be obtained by collecting groundwater, sediment and surface water data, characterizing DNAPL in the subsurface, updating the conceptual Site model, and re-evaluating ARARs, cleanup levels and points of compliance. It is expected these actions will take up to four years to complete, at which time a protectiveness determination will be made. It is likely that some uncertainties will always remain regarding DNAPL location and potential for discharge into sediments and surface water.

Marine Sediments Unit

The sediment cap monitoring has indicated that the MSU remedy is currently performing as designed, based on general attainment of the chemical and biological Sediment Management Standards within the stated scope of the MSU O&M Monitoring Program. However, a protectiveness determination of the remedy at the Marine Sediments Unit cannot be made until further information is obtained, as recommended in Section 9, Recommendations and Follow-Up Actions. Further information will be obtained by collecting groundwater, sediment and surface water data, updating the conceptual Site model, and re-evaluating ARARs, cleanup levels and points of compliance. It is expected that these actions will take up to four years to complete, at which time a protectiveness determination will be made. It is likely that some uncertainties will always remain regarding DNAPL location and potential for discharge into sediments and surface water.

Site-wide

A protectiveness determination for the overall remedy at the Pacific Sound Resources Superfund Site cannot be made until further information is obtained, as recommended in Section 9, Recommendations and Follow-Up Actions. Further information will be obtained by collecting groundwater, sediment and surface water data, updating the conceptual Site model, and re-evaluating ARARs, cleanup levels and points of compliance. It is expected that these actions will take up to four years to complete.

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Pacific Sound Resources Superfund Site
Seattle, King County, Washington
Second Five-Year Review Report

1 Introduction

There are two Operable Units at the Pacific Sound Resources (PSR) Superfund Site located in Seattle, King County, Washington. This is the second Five-Year Review for the Upland Unit (UU) and the first Five-Year Review for the Marine Sediments Unit (MSU). The prior Five-Year Review report evaluating the remedial actions of the UU was issued in September 2004. The sediment cap remedy for the Marine Sediments Unit was completed in 2005, within this five-year period. The first Five-Year Review for the UU was the schedule-triggering event for the current Five-Year Review, which covers the period from 2004 to 2008 for both Operable Units. The review was conducted between November 2008 and September 2009. This report documents the results of the review.

1.1 The Purpose of the Review

The purpose of Five-Year Reviews is to determine whether the remedy at a site is protective of human health and the environment. The methods, findings, and conclusions of reviews are documented in Five-Year Review reports. Five-Year Review reports identify issues found during the review, if any, and recommendations to address them.

1.2 Authority for Conducting the Five-Year Review

The U.S. Environmental Protection Agency (EPA) prepared this Five-Year Review pursuant to the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) and the National Contingency Plan (NCP) (National Response Center 1981 published as 40 CFR §300). CERCLA §121(c) states:

> "If the President selects a remedial action that results in any hazardous substances, pollutants, or contaminants remaining at the site, the President shall review such remedial action no less often than each five years after the initiation of such remedial action to assure that human health and the environment are being protected by the remedial action being implemented. In addition, if upon such review it is the judgment of the President that action is appropriate at such site in accordance with section [104] or [106], the President shall take or require such action. The President shall report to the Congress a list of facilities for which such review is required, the results of all such reviews, and any actions taken as a result of such reviews."

EPA interpreted this requirement further in the NCP; 40 CFR §300.430(f)(4)(ii) states:

> "If a remedial action is selected that results in hazardous substances, pollutants, or contaminants remaining at the site above levels that allow for unlimited use and unrestricted exposure, the lead agency shall review such action no less often than every five years after the initiation of the selected remedial action."

EPA Region 10 conducted this Five-Year Review of the PSR Superfund Site in Seattle, Washington. Site inspection was conducted by EPA staff, Ravi Sanga (Remedial Project Manager) and René Fuentes (Hydrogeologist), in conjunction with US Army Corps of Engineers (USACE) staff, Miriam Gilmer and Craig Martin (Project Managers), Mandy Michalsen, John Wakeman, Chemine Jackels, Lisa Scott, Brenda Bachman and Gwendolyn Hannam.

2 Site Chronology

Table 1 summarizes, in chronological order, the major milestones or notable events for the PSR Superfund Site.

Table 1. Chronology of Site Events

Event	Date
Site Developed by J.M. Coleman Company	1909
Wood treating operations on site	1909-1994
Site ownership transferred to West Coast Wood Preserving Company (jointly owned by J.H. Baxter Co. and Walter Wyckoff)	1959
Site ownership transferred to Wyckoff Company	1964
Site characterization done under RCRA § 3013 Order until added to National Priority Listing in 1994	1984
Name change from Wyckoff Company to Pacific Sound Resources	1991
Site ownership transferred from Wyckoff/Pacific Sound Resources to Port of Seattle with Prospective Purchaser Agreement (PPA) from EPA	August 1994
Site added to the National Priority Listing	1994
Consent decree entered between PSR principals and EPA, creating an environmental trust for funding cleanup actions	August 1994
Administrative Order on Consent (AOC) issued by EPA to Port of Seattle for upland removal actions	September 1994
Initiation of Upland OU Remedial Investigation/Feasibility Study (RI/FS)	1994
Time Critical Early Actions: Demolition of entire wood treating facility and removal of 4,000 cubic yards of contaminated soil and process sludge, and initial redevelopment of PSR as an intermodal rail yard and container terminal	1995
Non-Time-Critical Early Actions: Installation of slurry wall and Lighter Than Water Non-Aqueous Phase Liquids (LNAPL) recovery trench and completion of asphalt cap over layer of clean fill	1996-1998
Initiation of Marine Sediments OU RI/FS	1996
RI/FS for Upland OU Completed	November 1998
Inspection and maintenance of surface cap begins	1998
Public comment period for RI/FS reports and Proposed Plan for the PSR Site	April–May 1999

Table 1. Chronology of Site Events (continued)

Event	**Date**
Record of Decision (ROD) issued stating that the Early Actions for the Upland OU were the final action with additional requirements to ensure the actions remain protective, including: (1) inspection and maintenance of the surface cap, (2) conformational monitoring including groundwater sampling and Light Non-Aqueous Phase Liquid (NAPL) recovery; (3) Institutional Controls to prohibit groundwater use and restrict land use; and (4) ACLs (misconstrued and inappropriate)	September 1999
Assessment of potential damage to slurry wall as result of 2001 Nisqually earthquake; wall determined to be functioning effectively	2001-2002
Assessment and repair of damage to monitoring wells as result of 2001 Nisqually earthquake	2001-2003
Supplemental AOC issued to Port of Seattle by EPA for groundwater monitoring of shallow and intermediate monitoring wells to expend remaining funds committed to the site by the Port in 1994 PPA.	December 2002
Additional monitoring wells installed to complete the performance or compliance monitoring network	May 2003
Performance or compliance groundwater monitoring begins	May 2003
Marine Sediments OU cap design complete	2004
First Five-Year Review completed	2004
Marine Sediments OU cap completed	2005
Preliminary closeout report (PCOR)	September 2005
Long-Term Sediment Monitoring Report approved	2008
Upland groundwater monitoring program responsibility transferred from Port of Seattle to USACE. Port PPA funding obligation completed.	2008
Interim Upland Groundwater Monitoring Report completed by USACE	March 2009
Second Five-Year Review	September 2009

3 Background

The PSR Superfund Site is a former wood treating facility located on the south shore of Elliot Bay at 2801 S.W. Florida Street, Seattle, Washington (Figure 1). Wood was treated at PSR from 1909 to 1994 using preservative chemicals including creosote, pentachlorophenol (PCP), and metals. Soil, groundwater and marine sediments were impacted by these historical operations and Non-Aqueous Phase Liquids (NAPL) remain present in the site subsurface. Some NAPLs (fractions) are lighter than water (LNAPL) and float in the water table, and in others they are denser and sink (DNAPL). Volumtrically, most NAPL at the Site is DNAPL

Wood treating operations changed through time at the PSR site. The plant evolved from a small pile-supported facility constructed in a subtidal zone over water in the early 1900s to a relatively large treating facility constructed on fill. The original wood-treating facility consisted of one shed (eventually known as the "main shed") with one retort in operation. Additional retorts were installed in 1912 (four retorts), 1927 (two retorts), 1961 (one retort) and 1967 (one retort). The main dock on the northern terminus of the PSR site was constructed before 1917. There are no recorded dates for the construction of other former PSR structures. PSR layout prior to Early Actions is shown on Figure 2 and a photograph of PSR during operation is shown on Figure 3.

As noted previously, PSR is separated into two operable units, the UU and the MSU. The UU occupies approximately 25 acres and is located in an industrial portion of West Seattle, adjacent to the Lockheed West Seattle Superfund Site to the northeast, and otherwise surrounded by a fairly densely populated urban residential area. The nearest residence is over one-quarter of a mile from PSR. The UU and the surrounding areas to the east and the south are currently part of the Port of Seattle Terminal 5 intermodal yard. The property to the west is used as a barge transport facility for bulk material as well as a public access park (Jack Block Park). Figure 4 shows an aerial photograph of the site taken after redevelopment by the Port of Seattle. The MSU occupies 58 acres in Elliott Bay and lies directly north of the UU. It is divided into numbered Remedial Action subunits (RA1-RA5) as depicted in Figure 8.

3.1 Land and Resource Use

The UU south of the inner harbor line of PSR is currently owned by the Port of Seattle and is largely covered with asphalt, thus limiting habitat for most terrestrial plants and animals found in the Duwamish River/Elliot Bay region. The in-water portion of the Lockheed West Seattle Superfund Site, which was carved out of the West Waterway Operable Unit of the Harbor Island Superfund Site, and Elliott Bay are adjacent to the site and these water bodies are a portion of the adjudicated Usual and Accustomed fishing area of the Muckleshoot and Suquamish Indian Tribes.

During Early Actions, the north portion of the UU located adjacent to the shoreline was converted to the Jack Block Park, with fish advisory signs and fences preventing shoreline access. This public access area lies on property owned by both the Port of Seattle and the Washington State Department of Natural Resources. The remaining portion of the UU was completed as part of a larger intermodal terminal, which includes other property adjacent to PSR and is currently being leased by APL shipping. The renewable lease expires in 2029. PSR site use is anticipated to remain industrial in the foreseeable future, with the exception of Jack Block Park.

3.2 History of Contamination

Contamination at PSR is associated with former wood-treating processes and facilities. Investigation results indicated that releases of wood treating material occurred throughout the lifetime of the facility. The primary wood preservatives in use at the time of plant closure were creosote, PCP, and chemonite (an inorganic solution of copper, arsenic, and zinc salts). Other preservatives used during historical plant operations included phenol, chromium, boric acid, and fluoride (Science Applications International Corporation, 1990). During the investigation phase, concentrations of these constituents were evaluated. Based on this evaluation, the primary constituents of concern for the UU were determined to be polynuclear aromatic hydrocarbons (PAHs), pentachlorophenol, dibenzofuran, and zinc.

Specific sources within the former process area include:

- The former treating area.
- Treated-wood transfer and storage areas.
- Retort and transfer table discharge pits.
- Loading areas.
- Stormwater discharge areas.

The primary sources of contamination to the UU are associated with the treating areas, discharge pits, equipment, tanks, and loading areas. These primary sources were removed during Early Actions (demolition and materials removal) under CERCLA authority. The remaining sources of contamination at PSR are contaminated soils and groundwater with DNAPL and LNAPL. NAPLs occur in soil both above and below the water table. The volume of LNAPL at PSR is small relative to DNAPL. The DNAPL is potentially a contamination source to groundwater or to sediment and surface water directly. Upwelling contaminated groundwater could potentially affect sediment and surface waters in adjacent Elliott Bay and the larger Puget Sound.

3.3 Initial Response – Upland Early Actions

Cleanup actions for the UU of PSR were completed as Early Action Non-Time Critical Removal Actions (NTCRA). In significant part, the decision to proceed by NTCRA rather than a more traditional RI/FS followed by Remedial Design/Remedial Action (RD/RA) was driven by redevelopment plans by the Port of Seattle (Port). PSR was a difficult recalcitrant party. The Port sought the PSR property as a critical waterfront parcel for a new major container shipping terminal. The August 1994 Consent Decree settling the liability of the PSR principals (essentially personal covenants in exchange for all company assets) was entered simultaneously with the issuance of a prospective purchaser agreement (PPA) to the Port under which the Port agreed to cap the UU pursuant to an NTCRA Administrative Order on Consent from EPA as part of its terminal construction project. By proceeding in this manner, EPA was able to bring approximately $20 million in Port funds to the cleanup which would otherwise not have been available. The cleanup/redevelopment was hailed in speeches at the site by President Clinton, Vice President Gore and Administrator Browner, as a model for environmental cleanup and economic redevelopment to the benefit of all concerned.

No additional engineered remedial measures were required by the Record of Decision (ROD) (EPA 1999); however, the ROD discussed requirements to ensure that the remedy remain protective. Early Actions were completed at PSR to stabilize site conditions, remove some sources, address some principal threats posed by contaminated soil and groundwater, and allow for site redevelopment. The NTCRA were adopted as the final engineered remedial actions for the UU of PSR. NTCRA performed on the UU between 1996 and 1998 by the Port of Seattle included:

- Excavation and disposal of 3,840 tons of process residuals beneath demolished structures.
- Placement of a 4-inch to 8-inch thick low permeability asphalt cap to (a) isolate and prevent direct human exposure to contaminated soil and (b) minimize infiltration through impacted soil to groundwater.

- Installation of a 1,600 feet long by ~40 feet (bgs) deep bentonite slurry wall to (a) minimize shallow groundwater and LNAPL flow to Elliott Bay and (b) reduce tidal influence on contaminant movement.
- Installation of a 1,000-foot long by 15-foot deep LNAPL recovery trench on the inland side of the slurry wall to capture and prevent NAPL transport to Elliott Bay as a contingency measure.

Site stabilization and source removal actions were designed to eliminate near-surface, accessible volumes of wood-treating chemicals and process residuals in the upland. All above-ground structures were demolished and wood-treating chemicals contained in these structures were disposed of properly. A potential source of groundwater contamination was eliminated through excavation and disposal of approximately 3,840 tons (approximately 2,400 cubic yards) of process residual materials present in site soil.

Placement of a low permeability asphalt cap over the upland area of PSR reduced groundwater recharge and eliminated the potential for contaminants to migrate from unsaturated soil to groundwater via stormwater infiltration. Residual DNAPL was identified in the fill under former operational areas and in sand layers in the underlying native deposits.

The bentonite slurry containment wall was installed in 1996 to minimize shallow contaminated groundwater and LNAPL flow to Elliot Bay. This wall design was chosen because (1) it provided moderate compressive strength plus a reasonable degree of plasticity for "self healing" properties over time, (2) the low hydraulic conductivity ($1x10^{-6}$ cm/sec) of bentonite slurry would reduce the influence of groundwater flow and tidal fluctuations on contaminant movement, and (3) the design was the most cost-effective design over a 30-year design life (RETEC Group 1995). However, there was no continuous shallow, low-permeability layer into which the wall could be keyed to in order to create a containment cell which could have acted as a barrier against migrating DNAPL; the wall depth was chosen to minimize tidal effects on upland contaminated groundwater. Lateral extent of the slurry wall placement was based on observed NAPL and PAH concentrations in groundwater that exceeded 1,000 μg/L. An LNAPL collection trench was installed on the upland side of the slurry wall to capture LNAPL seeps, which had been observed along the beach prior to Early Actions. The center line of the recovery pipe was positioned at the water table depth predicted following slurry wall installation. However, following routine monitoring, no LNAPL was ever present or recovered in the recovery trench. Both DNAPL and LNAPL were left in place below and seaward of the slurry wall. Greater depth for the wall was rejected because a low-permeability layer into which the wall could be keyed to create a containment cell that DNAPL or groundwater could not migrate under could not be located, as well as cost considerations relative to environmental benefit. Absent a containment cell, there is no known depth below which DNAPL could not migrate, making a deeper wall clearly more expensive but not necessarily significantly more effective.

3.4 Uncertainties Associated with NAPL During the Early Actions and ROD

The Early Actions were adopted by the ROD as the final remedy. However, uncontrolled subsurface DNAPL veins or stringers remained following completion of the NTCRAs. Significant uncertainties remain regarding the extent of DNAPL in the subsurface, and the extent to which it will continue to affect adjacent media (groundwater and surface water). The ROD's conceptual site model (Figure 5) showed the generalized distribution of NAPL in the site subsurface on a north-south section view through the facility, and the connection between the UU and the MSU. Figure 13 shows a plan-view of the estimated extent of DNAPL represented by borings showing 2 inches or greater of intense hydrocarbon staining from creosote. Approximately 53,000 gallons of free-phase DNAPL remain in the shallow, intermediate, and deep subsurface zones on-site; of this, according to the ROD, approximately one-fifth, or 10,000 gallons, remains seaward of the slurry wall beneath land and sediment surface. DNAPL occurs in sand lenses for a significant distance beneath, and within an estimated 200 horizontal feet of the top of the Elliott Bay mud-line. Note that this conceptual model is based upon limited borings. No wells were completed in the aquifer subtending the affected aquifers at the site; thus, it is unknown whether the formation that occurs under the deeper site aquifer (Zone B, Figure 5) is an aquitard that prevents downward migration.

In summary, the Early Actions for soils and groundwater removed the most accessible contaminated source material, eliminated direct contact with subsurface soils, and appear to have eliminated LNAPL discharges to Elliot Bay.

3.5 Risks and Basis for Taking Action

3.5.1 Upland Unit—Human Health Risks

Pre-Early Action risks were greater than the acceptable risk ranges established by the NCP and the Washington State Model Toxics Control Act (MTCA) and established the need for CERCLA response action. The ROD stated that the Early Actions eliminated risks to upland receptors based on exposure to contaminated soil and vapor, since capping the upland area eliminated direct contact exposure with contaminated soil. In addition, the current and long-term use of the upland property as an intermodal rail yard and container storage facility assured that future residential as well as industrial exposures would either not occur or be controlled under an Institutional Control (IC) Plan. Under an industrial worker scenario estimated for conditions prior to the UU cap, the Incremental Lifetime Cancer Risks (ILCR) due to ingesting soil and inhaling vapors were as high as 1 in 100 (1E-02), primarily from PAHs, arsenic, dioxins and furans. Residential cancer risks prior to capping considered only the soil ingestion pathway, and were calculated to be as high as 1E-01 to 1E-02 ILCR. The pre-Early Action recreational site user scenario estimated a 1E-02 to 1E-04 ILCR.

3.5.2 Marine Sediments Unit—Human Health Risks

The basis for taking action with the Marine Sediments Unit resulted from pre-remedy incremental cancer risks for the Reasonable Maximum Exposure (RME) individual (tribal fisher) that were above the NCP risk range due to both PAHs and PCBs.

Wood-processing and related industrial chemicals released from the PSR UU or discharged from the Longfellow Creek overflow channel contaminated sediments which represented a threat to people consuming seafood from PSR. PAHs, PCBs, mercury, dioxins and dibenzofurans were considered in the risk assessment. Mercury was not detected in fish or shellfish tissue, and so was eliminated from further study.

Fish and sediments were found to contain contaminants associated with historical PSR activities. English sole was used as a surrogate species to represent bottom fish. Shellfish were evaluated because edible shellfish (primarily crab and shrimp) are found in the MSU. Clams were used as a surrogate species for all shellfish because of their close association with sediment and potential for human consumption; however, most shellfish consumption related to the MSU would consist of shrimp and crab because of the limited intertidal habitat available for clamming and restricted access to the shoreline.

Tribal fisher scenarios were evaluated using consumption rates for fish and shellfish from seafood consumption surveys of the Tulalip and Squaxin Island Tribes (Toy et al. 1996) (Liao and Polissar 1996) to represent Native American fish and shellfish consumption patterns specific to the Puget Sound area (though some assumptions associated with use of these surveys deviate from current policy regarding their present use). Exposure point concentrations for consumers of fish and shellfish under current conditions and various cleanup scenarios were determined using a sediment-to-biota transfer model. Of the site-related contaminants of concern in fish and shellfish that potentially impact human health, dioxins, furans and some PAHs, PCB, and PCP were considered to be the greatest risk. The potential cancer risks were evaluated using a toxicity equivalence (TEQ) approach. For carcinogenic PAHs (cPAH), concentrations were adjusted by toxicity equivalence factors (TEF) relative to the toxicity of benzo[a]pyrene. A similar approach was used for dioxin and furan compounds, comparing against the 2,3,7,8-tetrachloro-*p*-dibenzodioxin TEF. The ROD concluded that pre-remedy cancer risks to subsistence fishers were the primary human health concern and the basis for taking sediment remedial action. Pre-remedy incremental cancer risks for the RME individual (high-end tribal fisher) were above the NCP risk range due to both PAHs and PCBs. Pre-remedy non-cancer Hazard Indices were less than 1.0, with the exception of PCBs, for which contaminated seafood consumption indicated a Hazard Index of 4.

For the MSU, risk reductions were estimated following capping. For the selected remedy in the MSU, individual sample data collected as part of the RI were replaced with potential cleanup values. For dredged and capped areas, sediment contaminant concentrations were reduced to close to what was calculated to be anthropogenic Elliott Bay background concentrations. For predicted post-remedial action sediment concentrations for the chemicals of concern, clam and fish tissue concentrations were estimated using a biota-sediment accumulation factor for each sample location. The 90th percentile of the resulting tissue concentrations was used as the RME concentration in the residual human health risk assessment.

Table 2. Sediment Performance Standards
Per Washington State Sediment Management Standards (SMS)

Chemical	**Sediment Management Standards [a]**		**Apparent Effects Threshold [h,k]**	
	SQS [b,e]	**CSL[c,e]**	**LAET [i]**	**2LAET [j]**
Organics (ug/kg)				
Acenaphthylene	66,000	66,000	1,300	1,300
Acenaphthene	16,000	57,000	500	730
Anthracene	220,000	1,200,000	960	4,400
Benz(a)anthracene	110,000	270,000	1,300	1,600
Benzo[a]pyrene	99,000	210,000	1,600	3,000
Total Benzofluoranthenes[g]	230,000	450,000	3,200	3,600
Benzo(g,h,i)perylene	31,000	78,000	670	720
Chrysene	110,000	460,000	1,400	2,800
Dibenz(a,h)anthracene	12,000	33,000	230	540
Dibenzofuran	15,000	58,000	540	700
2,4-Dimethylphenol	29[h]	29[h]	29	72
Fluoranthene	160,000	1,200,000	1,700	2,500
Fluorene	23,000	79,000	540	1,000
Total HPAH	960,000[f]	5,300,000[f]	12,000	17,000
Indeno(1,2,3-cd)pyrene	34,000	88,000	600	690
Total LPAH	370,000[d]	780,000[d]	5,200	13,000
2-Methylnaphthalene	38,000	64,000	670	1,400
2-Methylphenol	63[h]	63[h]	63	72
4-Methylphenol	670[h]	670[h]	670	1,800
Naphthalene	99,000	170,000	2,100	2,400
Total PCBs	12,000	65,000	130	1,000
Pentachlorophenol	630[h]	690[h]	360	690
Phenanthrene	100,000	480,000	1,500	5,400
Phenol	420[h]	1,200[h]	420	1,200
Pyrene	1,000,000	1,400,000	2,600	3,300
Inorganics[h] (mg/kg)				
Arsenic	57	93	57	93
Cadmium	5.1	6.7	5.1	6.7
Chromium (total)	270	260	260	270
Copper	390	390	390	530
Lead	450	530	450	530
Mercury	0.41	0.59	0.41	0.59
Zinc	410	960	410	960

Notes:
a. MTCA Chapter 173-204 WAC.
b. Sediment Quality Standards.
c. Cleanup Screening Levels (also called Minimum Cleanup Levels if SQS are impracticable to achieve).

Notes to Table 2 (continued)

d. This value represents the sum of the following compounds: naphthalene, acenaphthylene, acenaphthene, fluorene, phenanthrene, and anthracene; the LPAH criterion does not represent the sum of the criteria values for the individual compounds.

e. Normalized to total organic carbon content (unless noted otherwise in table- see superscripts).

f. This value represents the sum of the following compounds: fluoranthene, pyrene,benz(a)anthracene, chrysene, total benzofluoranthenes, benzo[a]pyrene, indeno(1,2,3 cd)pyrene, dibenz(a,h)anthracene, and benzo(g,h,i)perylene; the HPAH criterion does not represent the sum of the criteria values for the individual compounds.

g. Sum of the concentrations of the "b," "j," and "k" isomers.

h.. Dry-weight basis. For PAHs, the AET value is used when sediment organic carbon is <0.5% or >4%.

i. Lowest Apparent Effects Threshold.

j. Second-lowest Apparent Effects Threshold.

k. Barrick, R.C. et al. 1988. *1988 Update and Evaluation of Puget Sound AET*. Vol. 1, *Sediment Quality Values Refinement*. Prepared for Tetra Tech, Inc. and EPA, Region 10, Office of Puget Sound. PTI Environmental Services, Bellevue, WA.

3.5.3 Marine Sediments Unit—Ecological Health

The ecological risk assessment evaluated the health of benthic invertebrate communities and bottom fish populations. The benthic community evaluation was based on multiple effects measures, comprising sediment toxicity bioassays, in situ benthic community structure, and clam tissue bioaccumulation data.

The bottom fish evaluation was based on fish tissue bioaccumulation data and an estimate of the transfer of bioaccumulative contaminants from a fish to its eggs. Chemicals of ecological concern were those that exceeded SMS, were bioaccumulative, or were widespread throughout PSR and exceeded Elliott Bay background concentrations.

Ecological receptors of interest included benthic crustaceans, mollusks, and polychaetes; and English sole. Chinook salmon and bull trout were also included as they were listed on the federal Endangered Species List. Sediment chemical data were compared with effects-based Washington State Sediment Management Standards (WAC 173-204-760) or the Puget Sound Apparent Effects Threshold (AET) values. Chemicals of potential concern found to exceed effects-based or background screening values in surface and subsurface sediment included low molecular weight PAHs, high molecular weight PAHs, PCP, dioxins and dibenzofurans, PCBs, and mercury. Mercury was not evaluated because it was not detected in fish or shellfish tissue. Surface sediment samples from nine MSU stations and two Elliott Bay background stations were also collected for acute laboratory bioassays (amphipods and sand dollar larvae), benthic community enumeration and identification, laboratory bioaccumulation tests using the clam *Macoma nasuta*, and analysis of English sole tissues. Clam tissues were analyzed for PAHs, PCBs, and dioxins and furans. Fish tissues were also analyzed for these COCs with the exception of PAHs, which were determined to be readily metabolized by fish, and thus not likely to be detected.

Exposure point concentrations were derived for sediment, benthic infauna, clams, fish, and fish eggs. Contaminant-specific exposure point concentrations for surface sediment were represented on a station-by-station basis, as averages of each major taxonomic group (i.e., crustacean, mollusk, and polychaete) and species-level abundance and richness. Sediment exposure point concentrations were represented by the laboratory results for PAHs, and polychlorinated dioxins and furans as TEQ. Concentrations of contaminants of concern were measured in unpurged, whole body bent-nose clam (*Macoma nasuta*) tissues exposed to site sediments. Contaminant exposure from bioaccumulation into English sole was estimated by measuring dioxin/furan TEQ in whole body adult tissues of fish collected from PSR. A maternal-egg transfer approach was used to model dioxin/furan exposures to fish eggs (Nimi 1983 and EPA 1993a).

Ecological effects for benthos were assessed by growth and mortality responses of amphipod, echinoderm embryo, and clam exposed to sediment collected from PSR to responses of organisms in clean control sediments; comparison of site-collected benthic infaunal community abundance and diversity; and predicted toxicity to English sole and its eggs. Critical comparisons were made with SMS threshold chemical criteria (Table 2) and biological criteria. Comparison was made to background concentrations of chemicals in clam tissue. Toxicity to fish and eggs was evaluated against both literature-based effects concentrations in fish tissues and background. Deleterious impacts were determined to occur to clams exposed to site-related contaminants at levels exceeding Elliott Bay background concentrations. No risks were identified for the existing conditions in the MSU to English sole or its eggs.

Prior to the remediation, adverse effects were predicted for some sensitive aquatic invertebrate species living in contaminated sediments at PSR. The ROD cited research by the National Marine Fisheries Service (Horness et al 1998) that suggested that flatfish (or other fish in direct contact with sediments) at PSR and throughout Elliott Bay may be at risk via impaired growth or reproduction, or via suppressed immune responses. Both PSR and the Elliott Bay PAH background concentrations exceeded this restoration goal; accordingly, English sole populations may be at risk throughout Elliott Bay due to non-site related sources.

3.5.4 Basis for Taking Action in the Marine Sediments Unit

The basis for taking action in the Marine Sediments Unit resulted from a combination of human health and ecological risk considerations. The basis for taking action with respect to human health resulted from pre-remedy incremental cancer risks for the RME individual (tribal fisher) that were above the NCP risk range due to both PAHs and PCBs.

PAHs represented the primary contaminant of concern in the surface sediment and drove the basis for taking action for ecological risk purposes. The ROD selected remedy was to:

- Cap areas of contaminated marine sediments greater than -10 feet mean lower low water (MLLW) that exceed the CSL* for PAHs, or the SQS for PCBs (Table 2). Cap areas with depths equal or shallower than -10 feet MLLW that exceed the SQS for PCBs.
- Dredge the area north of Crowley Marine Services to maintain navigational depths and access.

*Where individual PAHs exceed the organic-carbon normalized CSL, or the dry-weight based LAET. The 2LAET is used when sediment total organic carbon is below 0.5 percent.

4 Remedial Actions

The following section details the remedial actions selected for site soil, sediment, and groundwater, the status of their implementation, and site operation and maintenance.

4.1 Remedy Selection and Implementation

The PSR ROD was issued on September 30, 1999 and described the final selected remedies for the two operable units. These selected remedies are described below.

4.1.1 Upland Unit

Remedial action objectives for the UU are stated in the ROD as follows: *(1) protection of aquatic life in surface water and sediments from exposure to contaminants of concern above protective levels, and (2) protection of humans from exposure to groundwater containing contaminants of concern above protective levels.*

The NTCRAs completed at the time of the ROD were determined to be the final remedy for the UU. These Early Actions were demolition of all on-site structures, removal of highly contaminated shallow soil and sludge; focused NAPL collection and disposal; and isolation of remaining contaminated soil and groundwater with a low-permeability asphalt cap and installation of a subsurface slurry wall to control LNAPL. In addition, an Inspection and Maintenance (I&M) program for the UU surface cap, ongoing monitoring of groundwater and collection of NAPL as needed, and ICs for prohibiting groundwater use and restricting land use were selected as part of the final remedy. Early actions were completed and the I&M program began in 1998 and is ongoing (Section 2, Site Chronology). The misconstrued ACLs were never fixed.

4.1.2 Marine Sediments Unit

The remedial action objectives for the MSU as stated in the ROD are as follows: *(1) minimize human exposure through seafood consumption and (2) minimize benthic community exposure to site contaminants.*

The primary remedy was placement of a 3-foot thick containment cap over 58 acres of contaminated sediments, except in intertidal areas where a 5-foot thick cap was placed to allow for unrestricted tribal harvest of shellfish as required by tribal treaty rights. Additional actions included dredging of 10,000 cubic yards (cy) of contaminated sediment to maintain navigational access, removal of 800 unused creosote-treated pilings, and monitoring of cap performance. ICs to prohibit large anchor use in the capped area are being coordinated between the EPA, Tribal Governments and the US Coast Guard, but have not yet been completed.

4.1.3 Recently-Identified Protectiveness Issues

1. The remedy did not adequately address the uncertainties related to the migration of DNAPL at the site. Uncontrolled migrating DNAPL "stringers" may be releasing contamination into Elliott Bay as either non-aqueous phase product or upwelling dissolved phase in groundwater.

As described in Section 3.4, the ROD acknowledged that subsurface DNAPL veins or stringers remained following completion of the Early Actions in the UU. The DNAPL stringers were portrayed as extending from the UU into the MSU, i.e., beyond and/or beneath the slurry wall into the subsurface sediments in Elliott Bay.

Although there is no information that definitively demonstrates DNAPL continues to migrate from subsurface source materials into an environment where exposure could occur, potential risks to human health and the environment from dissolved-phase or non-aqueous phase intrusion into Elliott Bay from the known DNAPL stringers are assumed to exist, and were not adequately characterized or otherwise addressed in the RI/FS. More information is needed. It is currently unknown whether DNAPL or freely dissolved constituents are reaching or may reach the mud-line in the intertidal zone or anywhere in Elliot Bay now or in the future. There has however, been only a minimal amount of investigation to attempt to assess these risks. While the extent of DNAPL and its release or potential release into the Bay may never be fully characterized, additional investigation should reduce the substantial uncertainty around this important question.

2. Incorrect Substitution of Alternate Concentration Limits (ACLs) for drinking water ARARs.

The ROD misconstrued the very limited basis for ACLs in CERCLA Section 121(d)(2)(B)(ii). Since the ROD concluded that at least a portion of the groundwater beneath the site (at depth and farthest up-gradient from the shoreline) was likely to be potable, MCLs were relevant and appropriate requirements for such potable groundwater, and ACLs are only viable as a substitute for applicable requirements (e.g., state antidegradation laws or rules), never for relevant and appropriate requirements.

The ROD stated that, "based on the groundwater classification at PSR (Class IIb and Class III, i.e., non-potable), the impracticability of restoration, and the impracticability of the site meeting the statutory requirements, use of ACLs at PSR is appropriate." This statement contains several inaccuracies. Class IIb aquifers are potential future drinking water sources. Where doubt exists regarding the status of primary drinking water standards (MCLs, or nonzero MCL Goals (MCLGs) as Applicable or Relevant and Appropriate Requirements (ARARs), potability should be determined empirically using regulatory criteria rather than aquifer classifications or other designations (see Section 121(d)(2)(B)(i) of CERCLA). More importantly, as noted above, ACLs were never intended as a substitute for MCLs. In accordance with Section 121(d)(2)(A)(ii) (last sentence), MCLs and the stricter of federal Ambient Water Quality Criteria (AWQC) or state Water Quality Standards (WQS) must be met or waived where they are relevant and appropriate. If a Technical Impracticability (TI) waiver is invoked for any of these ARARs, it must be documented in a formal waiver pursuant to Section 121(d)(4)(C) of CERCLA. The application of ACLs is limited to applicable requirements (e.g., to groundwater in potable aquifers subject to an anti-degradation rule which (1) meet MCLs; and (2) based on known or projected points of entry of groundwater into surface water, there will be no statistically significant increase in surface water hazardous constituent concentrations from the groundwater at the point of entry. This use of ACLs is very limited. ACL use at PSR was far more expansive and intended for purposes far beyond the scope of Section 121(d)(2)(B)(ii). The PSR ACLs were so expansively calculated that some were set above solubility limits (see Issue 3, below).

Groundwater potability requires additional evaluation. WAC 173-340-720(1)(c) states, "Ground water cleanup levels shall be established at concentrations that do not directly or indirectly cause violations of surface water, sediments, soil, or air cleanup standards established under this chapter or other applicable state and federal laws." Whether PSR groundwater must meet or waive MCLs or MCL Goals (MCLGs) ultimately depends upon a determination of whether they are relevant and appropriate, which for groundwater is generally based on potability. Figure 12 shows the State of Washington's considerations for determining cleanup standards related to potability. WAC 173-340-720(2)(a) states that an aquifer is potable if it "could be used as a current or future water supply" (that is, sustain a pumping rate suitable for a water supply), and 173-340-720(2)(b) states that it must have "sufficiently low salinity." Neither of these conditions for potability was met in the saline, contaminated shallow groundwater near the PSR shoreline, indicating at least some of the site groundwater may not be drinkable. PSR groundwater at greater depths and also more distant from the shoreline requires additional empirical data to determine whether potability criteria are met in these portions of the aquifer.

Further, WAC 173-340-720(2)(c) requires a demonstration that contaminants which exceed groundwater quality standards published in WAC 173-200 are unlikely to be transported from a contaminated aquifer to groundwater that is a current or potential future source of drinking water, as defined in 173-340-720(2)(a) or 173-340-720(2)(b). Thus there are three significant data gaps confounding the evaluation of the WAC 173-340-720(2)(c) requirement: a) whether vertical contaminant transport occurs from the contaminated aquifers to the deeper groundwater beneath the site through the Lawton formation, b) whether the deeper water body is a current or potential future source of drinking water; and c) whether fresh water in the near-surface aquifers is degraded by site contaminants. None of these conditions is currently documented, preventing a potability determination at this time.

Since ACLs may not be used in lieu of relevant and appropriate requirements such as MCLs, to the extent that potable water is present in a site aquifer or in an adjacent aquifer that is, or could be, impacted by site contamination, drinking water standards would be relevant and appropriate requirements.

3. Misuse of the ACLs to measure protectiveness of surface water.

The potential for contaminated groundwater discharges into Elliott Bay was evaluated by establishment of the PSR ACLs (Table 4). These ACLs were derived groundwater concentrations intended to ensure surface water and sediment quality protection over a long period of discharge of groundwater to Elliott Bay. However, instead of measuring for the existence of any statistically significant increase in surface water concentrations of groundwater constituents, as ACLs selected in lieu of an applicable requirement (like a groundwater anti-degradation law or rule) are supposed to measure for, these ACLs merely measured whether some surface water ARARs (which would have to be met in any case) were being met. This allowed for extraordinarily lenient PSR ACLs which in some instances actually exceeded solubility limits and therefore could practicably never be exceeded. The ROD inappropriately established these ACLs as remedial action goals with coastal monitoring wells as alternate points of compliance. Multiple technical and legal issues have since been identified that greatly limit the utility of the tabled ACL values in compliance and protectiveness evaluations conducted before and during this Five-Year Review.

The ROD cited the Model Toxics Control Act (WAC 173-340-730(3)) for establishing surface water cleanup standards and noted that these were being met at the time of the ROD. The more stringent relevant and appropriate federal AWQC and applicable state WQS should have been cited as surface water ARARs; however these were cited only in the context of dredging and capping activities for the MSU. The ROD correctly listed Washington SMS as applicable requirements. Those requirements have a Cleanup Screening Level (CSL) which triggers the need for action (it may be overridden by sufficient biological testing) and a SQS which is the level of sediment cleanup action that must be achieved unless that is impracticable. Where impracticability can be demonstrated (like a CERCLA TI waiver) the CSL functions as the minimum cleanup level that must be achieved. The CSL is also called the minimum cleanup level because impracticability can not excuse or waive CSL compliance.

The Feasibility Study (FS) (EPA 1998) calculated ACLs as a means to project what it construed as probable compliance at the mud-line. The shoreline wells were the alternate points of compliance for meeting surface water standards. The FS modeled transition zone water concentrations at the mud-line in comparison to AWQC or stricter WQS. Compliance with the SQS was considered through equilibrium partitioning from pore water to sediment. The ROD stated that "there will be no statistically significant increase in contaminants in Elliott Bay after groundwater contaminant concentrations are attenuated between the shoreline wells and the marine water/sediment interface (i.e., the mud-line)." It is unclear what the basis was for this projected conclusion of "no statistically significant increase." The phrase commonly refers to any genuinely *measurable* increase based on a margin of error (as in opinion polling) or the precision of measuring instrumentation. However, the ROD compared resulting projected surface water concentrations solely to threshold values (AWQC, WQS, a pore water concentration that would result in exceedance of SQS in whole sediment), not to any genuinely measurable or statistically significant increase. The ROD concluded that surface water concentration increases could be characterized as insignificant as long as threshold concentrations were not exceeded.

As calculated during the FS, several ACL values for PAHs exceeded solubility limits for these compounds. These PAHs could therefore never be detected in surface water at their ACL value. These ACL calculations could lead to no ACL exceedance even if NAPL should be in or advancing towards a monitoring well. Nonetheless, it is useful to evaluate ACL exceedances for compounds below saturation in shoreline wells, because they may indicate increasing trends. For this reason the erroneous ACLs retain a very limited overall use in protectiveness evaluations.

Issuing a CERCLA Section 121(d)(4)(C) TI waiver for DNAPL constituents in groundwater and/or surface water would have been very difficult at the time of the ROD, and will require additional data and evaluation now. TI waivers require a rigorous demonstration that they are employed to as limited an extent as practicable and, most critically, that the site will remain protective of human health and the environment. A cleanup standard for potable groundwater would be required to be as close to drinking water standards as practicable, and surface water

ARARs would also have to be achieved to the maximum extent practicable. Such waivers would also require that contaminated groundwater discharges to surface water be documented and controlled to the maximum practicable extent. Such demonstrations could not be made with present information.

In summary, because of the problems with the use of ACLs as cleanup levels in the ROD described as Issues 2 and 3, this Five-Year Review compares available data against potentially relevant and appropriate drinking water standards, surface water ARARs, the SQS, and, for limited informational purposes only, against the PSR ACLs.

4.2 System Operations, Maintenance, and Monitoring

O&M Plans for both the UU and MSU were developed during or prior to 2004. These plans are administrative documents that describe O&M activities to be conducted. The UU and MSU O&M plans are being combined and the comprehensive O&M plan is scheduled for completion in 2009-2010.

Components of the O&M plans include:

- Inspection and Maintenance (I&M) Plan for the Public-Access Area at the PSR Superfund Site (RETEC Group 1998a).
- I&M Plan for the Asphalt Cap and Associated Stormwater System Revision 1 (RETEC Group 2004a).
- Upland Groundwater Remedy Confirmational Monitoring Plan (RETEC Group 2004b).
- Upland Groundwater Remedy Sampling and Analysis Plan (RETEC Group 2004c).
- Final MSU Operation, Maintenance, and Monitoring Plan (OMMP), PSR Superfund Site (USACE 2004).

Costs to date are shown in Section 7.1.5.

5 Progress Since the Last Five-Year Review

A 58-acre sediment containment cap was placed in the MSU. During construction, daily bathymetry surveys and material placement maps showing the GPS location of each bucket of material placed in RAs 1-4 were reviewed by USACE construction oversight personnel. Oversight of material placed in RA5 by bottom dump barge occurred by barge measurement and GPS location tracking of the barges during placement. These methods allowed oversight personnel to determine the volume of material loaded and off-loaded, and the location of the barge during placement. All records indicate that material volume and placement met design requirement in RAs 1-4, and that the designed volume of material was released from barges over RA5.

Following construction, three monitoring events occurred on the sediment cap with the following results:

(1) A post-construction monitoring event in 2005 to provide information for as-built surveys. Methods included bathymetric surveys in RAs 1-4 and through-cap cores in RA5. Results indicated that designed cap thickness was not achieved in RA5.

(2) An interim monitoring event for RA5 in 2006 to determine if the RA5 cap met chemical criteria and prevented exposure. Methods included surface sediment collection and chemical analysis and through-cap cores. Results of 11 surface sediment chemical analyses indicated that although cap thickness had not been achieved, surface sediment met chemical criteria (i.e., the SQS) in all samples. This area will require additional material to meet design specifications and it was determined that additional capping would occur based on the availability of suitable material.

(3) Monitoring of the entire sediment cap in 2007 to determine compliance with chemical standards and assure physical stability of the cap as required in the PSR OMMP. Methods included surface sediment collection and chemical analysis, through-cap cores, and bathymetry. Results indicate that the sediment cap is in compliance with the SQS with the exception of one sample in RA5 and that the cap is remaining physically stable. However, erosion and accretion of material along the swash zone suggest that more accurate measurement may be required in the future to identify if contaminated material may be exposed.

Groundwater monitoring is ongoing in the UU. Between November 2004 and February 2006, the Port of Seattle conducted six quarterly groundwater monitoring events and conducted the first Five-Year Review for the UU. The first Five-Year Review concluded that the remedy for the Upland Unit was protective of human health and the environment. However, all conclusions at this time were still being based on the erroneous PSR ACLs. Confirmational sampling was recommended to continue and ICs were recommended to be put in place to assure future protectiveness. At the time of the last Five-Year Review, the remedy for the Marine Sediments Unit was anticipated to be protective of human health and the environment on completion. EPA has since taken over groundwater monitoring from the Port of Seattle after the Port reached its upper limit of monetary commitment to the site in its 1994 PPA In 2008, EPA conducted an interim groundwater monitoring event to support this Five-Year Review. At that time, lack of monitoring data in deep groundwater monitoring wells was identified by EPA as a data gap; therefore, two historically NAPL-free monitoring wells (MW-15D and MW-3D) were added to the monitoring program. The Port of Seattle is voluntarily continuing the DNAPL volume recovery program consistent with previous years (at some point EPA may assume this also). DNAPL recovery volumes (see Attachment 8) were comparable to volumes recovered during previous years. Monitoring has occurred in the MSU and Upland ICs are currently in place. EPA is working on implementing the restricted navigation area with the US Coast Guard and the affected Indian Tribes.

6 Five-Year Review Process

6.1 Administrative Components of the Five-Year Review Process

Development of the process for the second Five-Year Review for the PSR Superfund Site, identification of the review team, and establishment of the review schedule was completed in summer 2008. The Five-Year Review team was led by Ravi Sanga, EPA Remedial Project

Manager (RPM) for both OUs, with technical support from USACE team members Miriam Gilmer (Project Manager), Mandy Michalsen, and John Wakeman. Additional EPA team members were René Fuentes (hydrogeologist), Charles Ordine (Regional Counsel) and Cindy Schuster (Public Involvement). The review schedule included the following components as described in this section:

- Community notification and involvement.
- Document review.
- Data review.
- Site inspection.
- Development of this Five-Year Review Report.

6.2 Community Notification and Involvement

A newspaper advertisement announcing that EPA was conducting the second Five-Year Review and welcoming public participation was published in the Seattle Times and the Seattle Post Intelligencer on Monday, November 24, 2008 (Attachment 1). Other components of community notification and involvement during the past five years included creation and distribution of technical documents and fact sheets, as well as repository updates to the project library at the EPA Region 10 Office. EPA's web page for the Pacific Sound Resources Superfund Site (EPA 2009) also contains the most up-to-date information on activities at the site.

Documents made available to the public since the last Five-Year Review include[1]:

- Preliminary Closeout Report, September 2005.
- Fact Sheet: Plans Move Forward to Protect the Pacific Sound Resources Cleanup, April 2006.
- 2007 Monitoring Report (SAIC 2007).

There was no expressed public interest or participation during the input period.

6.3 Document Review

Numerous documents were reviewed prior to and throughout preparation of this second Five-Year Review Report. The specific documents are listed in Attachment 2.

6.4 Data Review and Evaluation

Data collected as part of both the UU and MSU monitoring programs were evaluated to ensure sufficient data quality to review site conditions and concentration trends in upland groundwater and surface sediment quality for this Five-Year Review Report.

[1] All listed documents are available on line at:
http://yosemite.epa.gov/r10/cleanup.nsf/7780249be8f251538825650f0070bd8b/a595d5941c31443988256548005a94cf?OpenDocument

There were a total of 13 groundwater monitoring events in the upland area since the remedy was implemented. A total of seven groundwater monitoring events have occurred since the last Five-Year Review. These events began in November 2004. The recent events were February, May, August, and December 2005; February 2006; and September 2008. The first six events were completed by the Port of Seattle using the standard groundwater monitoring program on site. The seventh event was completed by USACE Seattle District as an interim measure following the procedures described in the EPA-approved Sampling and Analysis Plan prepared by the Port. The purpose of the interim event was to collect additional groundwater monitoring data using consistent data collection and analysis procedures as performed by the Port and to continue the concentration trend analysis in upland groundwater monitoring wells in support of this Five-Year Review. The sole change to the Port Sampling and Analysis Plan for the interim event was that two deep groundwater wells (MW-3D and MW-15D) were monitored, in addition to the shallow and intermediate monitoring wells that constitute the existing monitoring. Data from the deeper aquifer was identified as a data gap.

A technical memorandum was prepared by USACE as part of the O&M Program to document the groundwater data quality review for upland groundwater for all 13 monitoring rounds completed to date (Attachment 3). The data were found to be usable for the purpose of trend analysis. However, high analyte concentrations and/or interferences resulted in elevated reporting limits in some cases. USACE recommended that refined analytical strategies be considered in future monitoring events to achieve reporting limits that are at or below performance standards.

One bathymetric post-construction survey (2005) and two long-term monitoring events have been completed in the MSU, and were reviewed for this Five-Year Review.

6.5 Site Inspection

The site inspection was conducted on 19 November 2008 between hours of 0800 and 1100, by Ravi Sanga (Remedial Project Manager), René Fuentes (hydrogeologist) of EPA, and USACE team members Miriam Gilmer, Mandy Michalsen, John Wakeman, Chemine Jackels, Lisa Scott, and Gwendolyn Hannam, along with Warren Hansen (Port contractor) and Gary Young (Eagle Marine Services, Ltd., Port tenant). The site interviews were conducted between the hours of 1100 and 1200 in a conference room on site, by USACE team members Mandy Michalsen and Gwendolyn Hannam. The detailed findings of the site inspection and site photos are summarized in Attachment 4. Overall, the main O&M deficiencies identified were worn painted markings on the asphalt cap surface and monitoring well caps that needed to be secured. Otherwise the asphalt cap and public access areas appeared to be well maintained and in good condition.

6.6 Interviews

During the site inspection, two key persons familiar with the maintenance and inspections of the UU were interviewed: Gary Young, in charge of site building and yard maintenance, and Warren Hansen, Port contractor performing annual inspections of the asphalt cap and public access areas. Both had generally positive comments on site conditions and identified no significant issues or concerns. See Attachment 4 for a detailed summary of their comments.

6.7 Applicable or Relevant and Appropriate Requirements

The following ARARs in the ROD are relevant to a Five-Year Review (those related solely to construction of the remedy are not included in this list):

Upland Unit

- Washington State Model Toxics Control Act (MTCA) WAC 173-340-720(1)(C) for establishing groundwater cleanup levels.
- MTCA WAC 173-340-440 for ICs.
- MTCA WAC 173-340-730(3) for surface water cleanup standards.
- MTCA WAC 173-340-360(4) and (6) for cleanup technologies and restoration timeframes.
- MTCA WAC 173-340-704 through 706 for use of MTCA Methods A, B and C. Many other MTCA sections could or should have been included, though this citation could be interpreted as a catch-all, given MTCA cross section referencing and the ubiquity in MTCA of these methods. MTCA's more stringent than CERCLA Excess Cancer Risk Range, e.g., is applicable to both units.
- ACLs inappropriately replaced MCLs (and non-zero MCLGs) and any more stringent state groundwater water standards per the first bullet above.

Marine Sediments Unit

- MTCA (WAC 173-340-440) for establishing ICs.
- The Federal Water Pollution Control Act (Clean Water Act) (33 USC 1251-1376 and 40 CFR 100-149), and State Water Pollution Control Act (RCW 90.48) and regulations (WAC 173-216 and 220) and Water Resources Act (RCW 90.54) and WQS for Surface Water (WAC 173-201A) were cited but inappropriately limited to discharge to marine surface water only during cap placement and sediment dredging.
- Washington State Sediment Management Standards (WAC 173-204) for sediment.

As a part of the second Five-Year Review, chemical-specific ARARs were reviewed and summarized. See Sections 4.1.3 for a legal overview and 7.1.2 for listings of potential chemical-specific ARARs.

7 Technical Assessment

7.1 Question A: Is the remedy functioning as intended by the decision documents?

Answer: No. Cannot be determined at this time.

7.1.1 Remedial Action Performance and Monitoring Results

Overall the uplands work has been successful in meeting the ROD objective of protection of humans from exposure to contaminated groundwater. More information is needed as to whether the remedy is meeting the objective of protection of aquatic life in surface water and sediments and ultimately human health through ingestion of fish tissue. DNAPL was not adequately characterized or remediated. It continues to be present and may be migrating seaward, based on data from near-shore monitoring wells, and could affect the MSU or other areas through transition zone water.

Upland Unit and Groundwater

Due to the inadequacy of the PSR ACLs as protective performance standards, compounded by PSR ACL exceedances, it cannot be stated from information evaluated as part of this review that the remedy is functioning as intended in the ROD. A protectiveness determination cannot be made until protective performance standards are selected and incorporated into a ROD Amendment. The remedial action objectives for the UU (Section 4.1) clearly indicate that contaminant releases to surface water could result in a lack of protectiveness. Significant data gaps have been identified, namely groundwater quality as it affects surface water at the mud-line and the lack of near-shore sediment sampling data Figures 5 and 13 identify where current information suggests significant (greater than 2 inches of staining as seen in borings) possible extension of DNAPL into the MSU. (Also see Section 3.4.)

The following lines of evidence were evaluated in order to assess performance: concentration of COCs in groundwater, groundwater flow direction, DNAPL collection, and DNAPL thickness. The following was concluded:

- Site may have uncontrolled contaminants, both in groundwater as dissolved contaminants and as DNAPL in unknown locations under the site outside of the slurry wall.
- ACL exceedances exist in numerous groundwater monitoring wells along the shoreline and ACLs in any case were set too high (above solubility limits for some PAHs) to be protective.
- DNAPL has been observed in previously unaffected wells.
- DNAPL is increasing in thickness in wells where it has consistently been observed, and/or in frequency of those detections.
- There are exceedances of potentially relevant and appropriate groundwater standards in near-shore monitoring wells in the uplands. (Note that no data have been collected in the groundwater/surface water transition zone near the mud-line, and that such data would be a better comparison for compliance with surface water standards where groundwater transitions to surface water.)

The UU groundwater monitoring network consists of nested shoreline wells spaced approximately 100 to 250 feet apart (Figure 7). Shallow monitoring wells (screened 5 to 28 ft below ground surface, [bgs]) were included to monitor groundwater discharging through the slurry wall, and intermediate depth wells (screened from 40 to 66 ft bgs) monitor groundwater discharging beneath the slurry wall. Groundwater quality monitoring in deep wells occurred during three events between April 1995 and July 1996, but was eliminated from the groundwater quality monitoring program because intermediate wells better addressed discharge potentials compared to deep wells (screened from 90 to 100 ft bgs) for the following reasons:

- According to the FS, flow under the slurry wall from the shallow fill behind the wall contributes to intermediate depth groundwater flow (RETEC Group 1998b).

- There is shorter groundwater travel distance from intermediate depth wells to Elliott Bay compared to the deep wells.

According to the FS, there is little tidal mixing at intermediate elevations. In the 2008 monitoring event, conducted to assess dissolved-phase contamination in deep groundwater, two historically NAPL-free deep groundwater monitoring wells (MW-3D and MW-15D) were included in the sampling list.

Groundwater Flow Direction

Prior to slurry wall construction, groundwater flowed in a northwest direction towards Elliott Bay. Studies conducted following slurry wall construction indicated that groundwater flow shifted in a northeast direction with some flow around the eastern slurry wall boundary in the vicinity of monitoring well RW-12S (RETEC Group 2006). Based upon review of static well elevation data, groundwater generally approaches from the south towards the slurry wall, mounds up against the wall to the north, and flows around the east and west wings of the slurry wall toward Elliott Bay.

DNAPL Collection and Thickness Measurements

DNAPL measurement and recovery from selected wells has been ongoing since 1996. Prior to 1998, wells EW-6, EW-7, MW-5I, MW-11D, RW-1I, and RW-1D were measured and pumped several times a month. After 1998, recovery occurred on a periodic basis ranging from monthly to quarterly from four wells (EW-6, MW-5I, RW-1I, and RW-1D). As DNAPL volumes diminished, recovery ceased in several wells.

The DNAPL collection program currently consists of pumping DNAPL from previously-impacted upland wells where accumulation has been observed. DNAPL was detected in five monitoring wells (RW-lI, RW-ID, MW-5I, MW-131 and MW-14I) during the second year of monitoring. All these wells have historically contained DNAPL except MW-14I, where trace DNAPL was detected in November 2004, August 2005, November 2005, and February 2006; however, DNAPL in MW-14I was not thick enough to be measured and was not recovered from this well. Tabulated DNAPL recovery information is provided in Attachment 8. DNAPL recovery volumes continue to be comparable to volumes recovered during previous years.

The two most recent DNAPL-containing wells are MW-13I, where DNAPL was detected during the first Five Year Review (dated 2004), and most recently MW-14I, which was documented as having DNAPL in 2008 during monitoring by USACE. Note that this well was drilled in 2003, and while the boring log indicated product in the soil during drilling, there had not been any detected DNAPL accumulation until 2008. DNAPL thickness monitoring has now been performed in monitoring wells MW-14S, MW-14I, MW-15IR, and RW-1S, where creosote odors were documented during sample collection, or where analytical results indicated elevated concentrations of PAHs. Two sampling methods used for DNAPL estimation, the cotton string technique and the interface probe method, both indicated that MW-14I contained 2 feet of DNAPL and MW-15IR contained 2.1 feet of DNAPL. No DNAPL was observed in monitoring wells MW-14S and RW-1S, and no LNAPL was observed in any of the monitored wells.

DNAPL Concentrations

Some of the main dissolved contaminants that have exceedances of any criteria from likely or potential ARARs include chrysene, naphthalene, total naphthalenes, pentachlorophenol (PCP) and likely dibenzofurans. In addition, DNAPL is of particular concern because all or most of a great number of PAHs are mobilized when DNAPL flows.

One additional major group of contaminants at the PSR site is creosote. There are many components of creosote that may not be detected in the water samples. Creosote is an oily material composed of hundreds of PAH contaminants. It is that oily material that becomes DNAPL. Creosote does not readily mix with water, and its density, which is many times greater than water, allows it to sink.

EPA analytical methods and regulatory conventions use only about 16 of those PAHs to characterize and regulate the contamination from creosote, but the creosote contains many more than those 16 PAHs.

DNAPL source material can cause both a dissolved fraction of contaminants, which dissolve into water and flow with the water, and also the DNAPL itself which flows as a separate phase, controlled by both gravity and the geologic formations it encounters. It is the persistence of DNAPL, its flow characteristics, and its many PAH components that make it such a problematic source of contamination and a "principal threat material" in a Superfund site. Table 3 provides a list of DNAPLs commonly found at wood treater sites.

While a water sample analyzed under routine analytical methods may show concentrations of about a dozen of the more soluble PAHs, creosote DNAPL has a significantly higher concentration of these same compounds (it can be over a 1000 times more concentrated). In addition, the oily DNAPL carries with it all the other oily compounds that may not easily dissolve. Therefore, it can carry hundreds of additional PAHs at thousands of times the concentration that would be routinely detected in water samples.

Table 3. DNAPLs at Wood Treater Sites

Contaminants Commonly Found at Wood Treater Sites*

ORGANICS

Halogenated aromatics[2]
Dioxins/furans[1]
Dibenzo-p-dioxins
Dibenzofurans
Furan
Halogenated phenols[1]
Pentachlorophenol
Tetrachlorophenol

Simple non-halogenated aromatics[2]
Benzene
Toluene
Ethylbenzene
Xylene

Polynuclear aromatic hydrocarbons[1]
2-Methylnaphthalene
Chrysene
Acenaphthene
Fluoranthene
Acenaphthylene
Fluorene
Anthracene
Indeno(1,2,3-cd)pyrene
Benzo(a)anthracene
Naphthalene
Benzo(a)pyrene
Phenanthrene
Benzo(b)fluoranthene
Pyrene
Benzo(k)fluoranthene

Other polar organic compounds
2,4-Dimethylphenol[1]
2-Methylphenol[1]
4-Methylphenol[1]
Benzoic acid[1]
Di-n-octyl phthalate
N-nitrosodiphenylamine

[1] **DNAPL(s)** in pure form.
[2] **LNAPL(s)** in pure form.

***Table adapted from** *Presumptive Remedies for Soils, Sediments, and Sludges at Wood Treater Sites,* (EPA 1995 Directive 540/R-95-128)

Groundwater Concentrations

Groundwater in wells near the shoreline has exhibited high concentrations of dissolved contaminants over the course of monitoring events since 2003. Recent data have shown that groundwater samples from monitoring wells MW-14I, MW-15IR, and MW-14S all had high detections of PAHs, PCP, and dibenzofuran (these wells are adjacent to the shoreline). Examples of high concentrations detected in monitoring wells include the following.

Comparison to ROD standards – PSR ACLs and MTCA:

- MW-14I had concentrations of up to 5,900 µg/L of PCP in 2003, three orders of magnitude above the ROD criteria (see Attachment 6 for additional groundwater concentrations compared to ARARs, or Attachment 5 for several potential ARARs besides ACLs, and Table 4 of this document for PSR ACLs and exceedances).
- Concentrations of total naphthalenes (calculated) in wells MW-14I, MW-15IR, and MW-14S were nine times the MTCA Method C value. MW-14I total naphthalenes exceeded the MTCA C level by a factor of 47. Total napthalenes (calculated) in well MW-14S ranged up to 9590 µg/L, in comparison to the MTCA value of 350 µg/L.
- Groundwater from monitoring well MW-15SR had detected PCP at concentrations of 220 µg/L, and MW-14S had PCP at 26 µg/L (estimated, because it was above the instrument calibration range), in comparison to the MTCA value of 4.9 µg/L, or Marine Chronic - Clean Water Act §304 at 7.90 µg/L.
- Previous PCP concentrations at MW-14I have been 5900, 3200, 2500, 2700, 2600, 2200, 1400, 41000, 34000, 1400, 1600, 1500, 560, and 5400 µg/L between 2003 and 2008 (see Table 5 and Attachment 7).

Comparison to other regulatory criteria (i.e., MCLs):

- Groundwater from monitoring well MW-15SR had detected PCP at concentrations of 220 µg/L, and MW-14S had PCP at 26 µg/L (estimated, because it was above the instrument calibration range), in comparison to the MCL value of 1 µg/L.
- Previous PCP concentrations at MW-14I have been 5900, 3200, 2500, 2700, 2600, 2200, 1400, 41000, 34000, 1400, 1600, 1500, 560, and 5400 µg/L between 2003 and 2008 (see Table 5 and Attachment 7).

Some of the main dissolved contaminants that have exceedances of potential ARARs include chrysene, naphthalene, total naphthalenes, and dibenzofurans. In addition, DNAPL migration (a major concern at this site) allows all or most of the different PAHs to be mobilized, unlike the limited few PAHs that are normally dissolved in water and monitored in an analysis for dissolved contaminants.

Attachment 6 shows the analytical results for the 13 monitoring events that have been carried out at the site since the remediation was completed, including the 2008 monitoring event.

Table 4 shows ACL exceedances over the course of different monitoring events, by well. Note that wells not shown did not have exceedances.

Table 4. ACL Exceedances by Monitoring Well

Well	**MW-15SR**	**RW-6SR**	**MW-14S**	**RMW-14S**	**RW-1S**	**MW-11R**	**MW-15IR**	**MW-14I**	**MW-16I**
Compound									
Anthracene								X	
Benzo[a]pyrene								X	
Benzo[g,h,i]-perylene				X	X	X	X	X	X
Chrysene								X	
Dibenzofuran			X						
Fluorene			X						
Indeno[1,2,3-cd]pyrene				X*	X	X	X	X	
Naphthalene								X	
PCP	X	X*		X	X			X	
Phenanthrene							X	X	

* This is a potential exceedance obscured by an elevated detection limit

Table 5. MCL and MTCA C Exceedances by Monitoring Well

Well→ Criterion	MW-11S	MW-3I	MW-3S	MW-6SR	MW-3D	MW-11IR	MW-15SR	MW-16I	RW-1S	RW-12S	MW-15D	MW-14I	MW-15IR	MW-14S
MCL	PCP*	PCP*	PCP*	PCP*	PCP*	PCP*		PCP*			Benzo[a]pyrene, PCP*	Benzo[a]pyrene*****, PCP**!**	Benzo[a]pyrene*, PCP**!**	Benzo[a]pyrene*, PCP**!**
MTCA C						cPAH TEQ*	cPAH TEQ*	cPAH TEQ*	Fluorene, Dibenzofuran		cPAH TEQ*	Total Naphthalenes, 2-Methylnaphthalene, Fluorene, Acenaphthene, Pyrene, Dibenzofluoranthene, Fluorene, cPAH TEQ*	Total Naphthalenes, 2-Methylnaphthalene, Fluorene, cPAH TEQ*	Total Naphthalenes, 2-Methylnaphthalene, Fluorene, cPAH TEQ*

Notes:
No symbol indicates a detected exceedance of the listed criterion
* A potential exceedance is obscured by an elevated detection limit or limits associated with the analytical sensitivity and sample dilution due to other analytes
! Concentrations exceeded the listed criterion multiple times.

Marine Sediments Unit

As described in Section 4.2, the long-term sediment cap monitoring program was established in 2004 to determine the physical stability of the completed cap to ensure that its ability to physically isolate contaminated sediments is not compromised, and to document surface sediment quality of the cap relative to the SQS (USACE 2004). The 2005 post-construction monitoring report (Anchor Environmental 2005), and the 2006 and 2007 monitoring reports (Science Applications International Corporation 2006, 2007) provide information regarding cap compliance with physical and chemical criteria. The long-term monitoring program included primary and contingency testing. The primary determination of cap compliance is based primarily on the ability of the cap in the biologically active zone set in the ROD for compliance (0 to 10 cm) to meet or be below the SQS for the COCs.

EPA included biological monitoring in 2007 (a contingent test) to strengthen the weight of evidence to support a determination that the MSU remedy is operational and functional. The 2007 monitoring event included 30 surface (0 to 10 cm) sediment samples and 15 subsurface sediment samples. Eight primary surface samples and four alternate location surface samples could not be collected due to grain size. Four primary subsurface samples and four alternate location subsurface samples could not be collected due to grain size. As shown in Figure 9, 23 of the surface samples were collected within the remediation areas RA2B, RA4, and RA5, and 7 samples (coded OSA) were collected outside the remediation areas to confirm that off-site sediment conditions were improved by incidental cap material deposition. Off-cap samples were collected to determine if incidental capping improved sediment chemical quality in areas that were between SQS and CSL. This was not a requirement set forth in the ROD, but was included for protectiveness measures. All subsurface samples were collected from RA5. Collection of surface sediments in RAs 1, 2a, and 3 was not possible due to the coarse grain size and “fish-mix” pebble substrate.

Based upon available chemical data, the MSU cap is meeting ROD performance standards and providing an effective barrier over the area it covers based on a comparison of sediment monitoring data to chemical and biological regulatory standards. Sediments in RA1, RA2a and RA3 were not sampled at the time of the long-term monitoring effort due to lack of sediment in those areas, which were primarily cobble. The sediment cap in RA5 was less than the physical design requirements for cap thickness, indicating construction was incomplete; and one station was slightly above the SQS for PCBs in an area that was insufficiently capped. The monitoring program required use of the SMS “cluster of concern” methodology when a single sample exceeded the SQS for any chemical. This method requires that three additional samples be collected and analyzed within the area to determine if additional remediation is necessary. An assessment by this method will be completed in the next monitoring event in 2012. The assessment was not completed in 2007 because the single sample exceedance in an insufficiently capped area did not warrant remobilization.

<u>Chemical Sampling Results</u>

All surface samples collected in RAs 2a and 4 met the SQS. Fourteen of the 15 RA5 samples on cap locations monitored in 2007 met the SQS. As illustrated in Figure 9, sample RA5-14a-S, exceeded the SQS for PCB (12 mg/kg organic carbon normalized, or OC). The primary sample result was 9.6 mg/kg OC, and the duplicate sample result was 18.0 mg/kg OC; the average of the two samples slightly exceeded 12 mg/kg OC. Because the cap thickness is negligible at this station, it is likely that PCBs represent residual site contamination. Two of the six OSA stations exceeded the SQS for multiple COCs, and at one, chromium exceeded the CSL.

<u>Physical Results</u>

Cap Thickness. Cap thickness measured by bathymetric survey in RAs 1 to 4 indicates that the cap is remaining physically stable. However, erosion and accretion of material along the intertidal shoreline suggest that more accurate or frequent measurements may be required in the future to identify whether material is truly eroded or 'lost' or if material is moving from one location to another from wave action along the shoreline with no significant erosion or loss.

The 2007 monitoring event shows an RA5 cap thickness ranging from 0 to 21.3 inches (Figure 10: yellow bars) indicating that no portion of the cap in RA5 met the minimum cap depth criteria of 27 inches. The average cap thickness was 9.7 ± 6 inches, or only about 36 percent of the design specification. Available coring measurements of cap thickness do not take into account the fractional recovery (actual core recovery/core penetration) from compaction within the core tube samples due in part to the very deep water at RA5. However, it is unlikely that the relatively small consolidated fraction representing the coarse sand cap would have compacted more than 25 percent within the core tube. If that value is assumed, only one RA5 station (RA5-03-C) has met design specifications.

Figure 10 also compares the 2005 cap depth survey for RA5 with the surveys from 2006 and 2007. The cap's mean thickness was 13.9 inches in 2005, 11.5 inches in 2006, and 9.7 inches in 2007. Based on the high variance in measurement, the monitoring data suggest high spatial variability in cap thickness across RA5. The decrease in the mean cap thickness from 2005 to 2007 may indicate self-weight consolidation as cap and sub-cap material compacts due to the added surcharge of the cap. Given the limited accuracy of these techniques it is unknown whether the cap is remaining stable in RA5. Chemical results will be required to determine protectiveness in this area until additional cap material is placed. Side scan sonar could help measure cap stability and sediment processes.

Shoreline Inspections. The shoreline cap condition was documented most recently in the 2007 Monitoring Report, which indicates some areas of the intertidal cap are eroding, while others are depositional with a maximum change of approximately 2 feet along a slope. In areas where pocket beaches were constructed, a berm evolved immediately after placement. This deposit of sandy material is likely the result of winnowing of finer grained material in the swash zone via sorting by wave action on the beach face. This site is essentially unprotected from wind generated waves from the northwest, and wakes from passing commercial vessels. These waves possess sufficient energy to mobilize and transport sand and pebble size grains on the beach face. Overall, the extent of change is not large enough to suggest that the thick intertidal cap function has been degraded and no further investigation in this area has been done.

Biological Results

To ensure further protectiveness, EPA made the decision to include biological testing during the most recent monitoring event, although such testing was not required according to the Washington Sediment Management Standards testing logic. (Normally, sediment chemistry is analyzed first, and only samples exceeding SQS are submitted for bioassay.) Twenty-three sediment samples from the PSR capped area and three reference sediments from Carr Inlet were collected in 2007 and assessed using the following test organisms and toxicity tests: 10-day amphipod (*Rhepoxynius abronius*) mortality test, the 48-hour larval (*Mytilus galloprovincialis*) development test, and the 20-day juvenile polychaete (*Neanthes arenaceodentata*) growth test. When all three bioassays pass these SMS biological interpretive criteria, the location passes all SMS standards. If one of three bioassays fails the SQS biological interpretive criteria, the location fails for the SQS. If two or more bioassays fail the SQS biological interpretive criteria or any bioassays fail the CSL biological interpretive criteria, the location fails for the CSL. Six locations passed all SMS criteria, 17 locations failed the SQS criteria, but no locations failed the CSL criteria.

Two quality control issues were identified for the bioassay tests that may affect the integrity of the results. The first is the interpretation relative to reference sediment, and the second was the overall performance of the larval test, which is considered inconclusive due to the poor gamete quality observed by the laboratory and the low initial stocking density of the test.

In the larval test, a relatively poor match between the grain size of the test sample and that of the reference stations from Carr Inlet occurred for some samples. The fines content from five test samples was higher or lower than the recommended 20 percent fines range of the reference sediment; therefore, these samples were compared to a "pooled" reference toxicity response with intermediate grain size. The pooled reference is a better comparison, since the percent fines of the test sediment was intermediate between the percent fines in the two pooled reference samples.

Sample RA5-14A passed the SQS biological interpretive criteria in comparison to the single paired reference bioassay, but failed the SQS criteria compared to the pooled reference bioassay. RA5-15 failed the CSL criteria compared to the single reference sample, but was less than the CSL in the pooled reference. Sample RA5-20 failed SQS criteria compared to a single reference bioassay, but passed SQS criteria compared to the pooled reference.

It is worth noting that larval test results have been difficult to interpret in other, non-Superfund programs in the past biennium. The PSR larval test results are believed to be invalid. They did not correspond with conclusions from either the chemistry analyses or the other two bioassays. Accordingly, the 2007 Monitoring Report concluded, "Area-wide toxicity was not anticipated based on the chemistry results for both the 2006 and 2007 monitoring events. It is possible the observed toxicity is the artifact of an overly sensitive bioassay due to the quality and density of the test larvae." Typically, under SMS, biological tests are used to confirm chemical criteria exceedances and will only be utilized in future monitoring if chemical exceedances occur.

Should the larval test be used in future long-term monitoring, the issues identified here will be scrutinized carefully to assure that its use provides meaningful information.

7.1.2 Review of Applicable or Relevant and Appropriate Requirements (ARARs)

See Section 4.1.3 for an evaluation of the legal status of the ROD ARARs for groundwater as drinking water and ACLs for surface water. This section lists potential ARARs for these media.

Surface Water Protection ARARs

Since the PSR ACLs are not protective and were not validly calculated, the more stringent of federal AWQCs from Sections 303 and 304 of the Clean Water Act and State WQS are ARARs as set forth in Section 121(d)(2)(A) and (B) of CERCLA. MTCA groundwater Method B (WAC 173-340-730(3)) is generally consistent with Section 121(d)(2)(A) and (B) of CERCLA.

Table 6 shows likely ARARs for site COCs. Attachment 5, Table A5-1 details the analysis used in identifying the values.

Table 6. Surface Water ARARs for Human Health and Aquatic Life

Contaminant of Concern	Lowest Requirement for Surface Water *(μg/L)*	Basis
Acenapthene	6.40E+02	Human Health
Anthracene	2.64E+04	Human Health
Benzo(a)anthracene	1.80E-02	Human Health
Benzo[a]pyrene	1.80E-02	Human Health
Benzo(b)fluoranthene	1.80E-02	Human Health
Benzo(k)fluoranthene	1.80E-02	Human Health
Chrysene	1.80E-02	Human Health
Dibenz(a,h)anthracene	1.80E-02	Human Health
Fluoranthene	9.00E+01	Human Health
Fluorene	3.46E+03	Human Health
Indeno(1,2,3-cd)pyrene	1.80E-02	Human Health
Naphthalene	9.58E+00	Human Health
Pentachlorophenol	3.00E+00	Human Health
Pyrene	2.59E+03	Human Health
Zinc	8.10E+01	Aquatic Organisms, Marine Chronic

Groundwater Protection ARARs

To the extent that site groundwater is empirically determined to be potable, including whether adjacent potable aquifers are impacted by site contamination, drinking water standards are potentially relevant and appropriate. (See Section 4.1.3 for discussion.) Table 7 shows the lower of MCLs and MTCA Method C values[2]. Attachment 5, Table A5-2 presents the analysis used in identifying the values.

Table 7. Potential Relevant and Appropriate Requirements for Groundwater

	Lowest Requirement for Drinking/Showering (µg/L)
Acenaphthene	2.10E +03
Anthracene	1.1E+04
Benzo[a]pyrene Equivalents	1.20E-01
Dibenzofuran	7E+01
Fluoranthene	1.4E+02
Fluorene	1.4E+02
2-Methylnaphthalene	7E+01
Naphthalenes (Total of naphthalene, 1-methylnaphthalene and 2-methylnaphthalene)	3.5E+02
Pentachlorophenol	1. E+00
Pyrene	1.1E+03
Zinc	1.1E+04

<u>Sediment Protection ARARs</u>

The SQS remain applicable sediment standards, as per the ROD.

7.1.3 Expected Progress Towards Meeting Remedial Action Objectives

Upland Unit

As defined by the ROD, the remedial action objectives for the groundwater pathway are: (1) protection of aquatic life in surface water and sediments from exposure to COCs above protective levels, and (2) protection of humans from exposure to groundwater containing COCs above protective levels. The protectiveness determinations for aquatic life were based on the incorrectly applied PSR ACLs (for which multiple exceedences have been observed). In addition, the potability of site groundwater has yet to be determined. For this reason EPA cannot assess progress toward meeting site groundwater RAOs, beyond stating that further investigatory work outlined in the Report is necessary to determine appropriate standards by which groundwater objections can be measured.

Marine Sediments Unit

As defined by the ROD, the remedial action objectives for the MSU are: (1) to minimize human exposure through seafood consumption and (2) minimize benthic community exposure to site contaminants. Progress towards meeting these objectives is evaluated using the SQS. These objectives were evaluated during the long-term monitoring of the sediment cap in 2007.

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[2] The complexity of the site and the numerous chemicals make Method A inappropriate; the industrial setting suggests that Method C for industrial sites would be appropriate.

Based upon chemical concentrations in sediments, all but one of the monitored locations met the SQS. The single exceedence was only slightly above the SQS. In the 2012 monitoring event, this location will utilize the "cluster of concern" methodology to determine if the area requires additional remediation. Biological tests generally indicate that the sediments are not toxic. Therefore, the sediment cap is performing according to criteria set in the ROD. However, EPA must still evaluate the effect of migrating DNAPL on the sediment cap through the possible infiltration of upwelling groundwater as discussed in the recommendations. Lastly, the cap for remedial action area 5 was not satisfactorily completed. The isolation depth required for long-term protectiveness will require future monitoring and placement of suitable capping material from a dredge source when it becomes available. Although upland material could be used, EPA determined that the use of dredge material was the most cost-effective method if the incomplete RA5 cap did not substantially exceed SMS criteria.

7.1.4 System Operations and Maintenance

A data collection program (described in Section 4.2 above) is in place for long-term monitoring of the UU and MSU.

7.1.5 Costs of System Operations, Maintenance, and Monitoring

Upland Unit

O&M activities for the UU selected in the ROD included I&M of the surface cap, monitoring of site groundwater, and collection of NAPL. The Port of Seattle had been completing all UU I&M activities since the completion of the NTCRAs through late 2008 per its limited commitment in its PPA from 1994. In September 2008, USACE was tasked to conduct the groundwater monitoring activities, funded by EPA through an Interagency Agreement. The Port continues to conduct the inspection and maintenance of the upland cap and collection of NAPL.

Marine Sediments Unit

USACE Seattle District conducted the monitoring at the MSU.

Costs

Table 8 displays the total Operations, Maintenance and Monitoring (OM&M) costs for the UU and MSU by calendar year. USACE was tasked with conducting the OM&M program for the MSU from the date of remedy construction completion to the present. The cap in RA5 requires additional material to be protective. EPA will evaluate options for appropriate cap enhancement.

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Table 8. Costs for System Operation, Maintenance, and Monitoring

Upland Unit

Project	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	Grand Total
T5 Environmental Programs		10,638.51	25,902.32	15,724.20	82,874.91	2,203.70						137,343.64
T5 Slurry Wall Assessment			7,110.81	64,873.81	7,596.97							79,581.59
Environmental Monitoring Wells Earthquake Repairs			8,885.00	58,266.97	51,598.61							118,750.58
T5 PSR Pile Demolition				3,038.25	497,195.33	1,927.34						502,160.92
T5 PSR EPA AOC - Cost for cap inspection					108,864.06	3,872.99						112,737.05
EPA T5 PSR Superfund						157,081.25	122,283.62	109,774.32	66,253.95	59,736.56	3,016.33	518,146.03
Site work, rail & buildings	4,693.82	1,828.65										6,522.47
PSR RI/FS & Cleanup	2,744.00											2,744.00
SWHP-Compliance monitoring for RA 4	635.57											635.57
T-18 Exp project controls	1,596.80											1,596.80
Grand Total	9,670.19	12,467.16	41,898.13	141,903.23	748,129.88	165,085.28	122,283.62	109,774.32	66,253.95	59,736.56	3,016.33	1,480,218.65

Marine Sediments Unit

Project	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	Grand Total
Corps of Engineers in-house							$645,427.81	$92,093.95	$169,641.09	$215,407.81	$211, 384.76	$1,333,955.42

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7.1.6 Opportunities for Optimization

Upland and Marine Sediments Units

There are no identified opportunities for optimization of the remedies at this time. Greater characterization of DNAPL extent and mobility in product phase and in groundwater in dissolved phase is necessary and establishing appropriate cleanup standards to replace ACLs, as proposed in this Five-Year Review, will permit a better understanding of the need for optimization and/or remedy amendment.

7.1.7 Early Indicators of Potential Remedy Problems

Upland Unit

PCP, dibenzofuran, and several PAHs exceeded the PSR ACLs at numerous upland groundwater monitoring wells (Table 4), and MCLs and/or MTCA groundwater cleanup standards for benzo[a]pyrene, cPAHs, total naphthalenes, fluorene, PCP, and dibenzofuran (Table 5). Increasing COC dissolved concentration trends and observations of additional DNAPL in numerous site wells indicate contamination may be increasing at these locations and migrating toward Elliot Bay.

Marine Sediments Unit

The sediment remedy meets chemical performance criteria outlined in the ROD, although there are clearly areas in remedial action area 5 where insufficient cap material was placed and/or migrated after placement. Migration of DNAPL stringers and the potential for discharge of contaminants to sediments and/or the water column will need to be addressed.

There is a significant data gap with respect to whether the remedy in the UU, in conjunction with the MSU cap, is protective. Because there are no relevant measurements of groundwater contaminants near the Puget Sound mud-line, more information is needed to determine whether contaminated upland groundwater currently impacts surface water or sediment quality, or whether migrating DNAPL itself may be discharging to surface water. The sediment O&M program has no sediment sampling locations in the near-shore areas to assist this determination; and the use of alternate points of compliance at the upland wells has resulted in the lack of collection of surface water samples. Sediment as well as pore water or surface water samples in the transition zone are needed (Section 7.3).

7.1.8 Implementation of Institutional Controls and Other Measures

Upland Unit

Restrictive covenants for land and groundwater deed use restrictions have been agreed to between the Port of Seattle and EPA and are in the process of being implemented.

Marine Sediments Unit

The no-anchor zone restriction has not yet been implemented. More coordination with the US Coast Guard is needed to establish this restrictive navigation area by federal rulemaking.

7.2 Question B: Are the exposure assumptions, toxicity data, cleanup levels, and remedial action objectives (RAOs) used at the time of the remedy still valid?

Answer: No. The use of ACLs and related assumptions were incorrect and are invalid. Appropriate identification of ARARs and related cleanup standards will be pursued and documented in a ROD amendment. Additional monitoring will help assess whether the revised cleanup standards are being met and whether any ARARs that cannot be met may qualify for a waiver.

7.2.1 Changes in Exposure Pathways

Upland Unit

Groundwater potability, RAOs, and cleanup levels need to be revisited to ensure protectiveness.

<u>Vapor Intrusion</u>

Vapor intrusion was not explicitly considered in the ROD. Although surficial soil removal and asphalt cap placement has been completed in the UU, during the site visit the project team concluded that an industrial worker exposure could occur in a slab-on-grade maintenance building (see Figure 11 for building location). Three PAHs (benzo[b]fluoranthene, naphthalene, and chrysene) may have sufficient volatility and toxicity to be of concern for evaluating the groundwater and soil to indoor-air pathway (EPA 2000). There are no recent updates on the toxicity of PAHs; the most recent found were in 1993 (EPA 1993b). EPA's Risk Assessment Guidance for Superfund, Part F (EPA 2009), should be considered in establishing defensible toxicity values for inhalation unit risk and inhalation reference dose. There are no current vicinity well or vapor data to use to calculate the potential for a soil or groundwater-to-indoor air pathway. Groundwater and vapor data will need to be collected in order to determine protectiveness for this pathway.

Marine Sediments Unit

<u>Ecological Health</u>

The SMS remain valid as protective criteria for the sediment cap.

Based on invalid ACLs, the ROD stated that monitoring data and modeling results indicated that groundwater would meet regulatory requirements at the point of discharge at the mud-line in Elliott Bay. However, after several rounds of monitoring, concentrations in several monitoring wells showed levels are significantly above even the ACL criteria. Since the modeled protective values have been exceeded and the assumptions of protectiveness the modeling was based on are no longer valid, an analysis of direct data at the groundwater to surface water transition zone (mud-line) will be necessary to document protectiveness given the concentrations at the monitoring wells. The current lack of surface and mud-line water quality data constitutes a major data gap in assessing remedy protectiveness for marine organisms.

<u>Human Health: Changes in Assessing Risk to Tribes from Seafood Consumption</u>

In August, 2007, EPA Region 10 published a framework for calculating consumption rates for assigning risks of tribal consumption of seafood (EPA 2007) which states it "is intended to be applicable at EPA cleanup sites within Puget Sound and the Strait of Georgia," and "is intended to be applied to *future decisions* in the RCRA and CERCLA programs." Therefore, this framework does not by its terms, affect previous remedial decisions. The framework refers to Five-Year Reviews as follows:

> "After a remedy has been selected, CERCLA requires that five-year reviews be conducted at any remedial action site that does not allow for unlimited use or unrestricted exposure. The purpose of the five-year review is to assure that human health and the environment will be protected by the remedial action.
>
> "As part of the five-year review process, Tribes can provide new information to be considered or request that the lead federal agency evaluate particular aspects of a remedy relative to Tribal interests. Such requests are most helpful when provided to the lead federal agency early in the five-year review process. Such requests would be evaluated on a site-specific basis and consistent with EPA's five-year review guidance. EPA would generally discuss the appropriate means for addressing a Tribe's concern with the Tribe during the review process.
>
> "While a CERCLA five-year review includes considering new information, such as new information regarding exposure rates and assumptions, it is important to keep in mind that remedies and cleanup levels at CERCLA sites are determined by many factors. In determining whether a recalculation of site risks or any other detailed analysis is needed as part of the five-year review, EPA would review the basis of the selection of the remedial action and cleanup levels and other relevant information to determine whether further analysis of such updated information is appropriate, and focus our analysis on matters that would help assess the protectiveness of the selected remedy."

The risk assumptions made in the ROD were based on a tribal consumption scenario, prior to EPA Region 10's development of the Tribal Framework which takes a different approach particularly with respect to assumptions in applying consumption survey data from assumptions applied in the ROD in addressing tribal fish consumption. The sediment cap still protects fish and shellfish from exposure to underlying sediment contaminants.

A Five-Year Review should determine whether a remedy is protective of human health and the environment at the time of the review. The human health tribal fish consumption risk calculations in the ROD were prior to EPA Region 10's development of the Framework, and were based on some tribal consumption assumptions that would be made differently were Framework assumptions applied now. The Framework however, emphasizes consultation with affected tribes, whose fish consumption patterns can differ markedly. During the public input period associated with this five-year review, no issues or concerns were raised by the affected Tribes. While formal consultation did not occur with affected Tribes, discussions on Five-Year Review issues did occur with the Tribes during Natural Resource Trustee briefings on the PSR long-term monitoring strategy. Tribal exposures will be considered again in subsequent statutory reviews or if new information that affects tribal consumption becomes available. In addition, EPA will consult with the Tribes before the proposed plan for the ROD amendment. The sediment cap prevents exposure to fish and shellfish from underlying sediment contaminants to

SQS levels; and absent recontamination should be fully protective over its lateral extent. Future evaluation and monitoring will be conducted on the cap to look at potential recontamination from surface sources and from groundwater.

7.2.2 Changes in Toxicity and Other Contaminant Characteristics:

Human Health

The Human Health Risk Assessment indicated that the excess carcinogenic risks at PSR were associated with PAHs, arsenic, dioxins and furans, and pentachlorophenol. Arsenic, pentachlorophenol, and PAH toxicity values (including B[a]P toxicity equivalence factors) have not changed since the ROD. Dioxins and furans were evaluated against background concentrations, not toxicity. Minor changes have occurred to the toxicity equivalence factors (World Health Organization 2005) that do not affect the scope of the remedy; however, if future calculations of Site and background risk are determined necessary, these changes will be considered.

Ecological Risk

Protection of surface water quality at the mud-line addresses protectiveness to benthic organisms. Any changes to toxicity values will be addressed as EPA decides on appropriate standards in lieu of the invalid ACLs during its amendment of the ROD.

7.2.3 Status of RAOs and Cleanup Levels

As discussed in Section 4.1.3 and elsewhere, the use of ACLs and related assumptions to establish cleanup levels was invalid. Appropriate identification of cleanup levels is needed and RAOs may need to be revised pending results of future investigation.

7.3 Question C: Has any other information come to light that could call into question the protectiveness of the remedy?

Answer: Yes. DNAPL has been newly detected in near-shore wells, and several contaminants seem to be increasing in the dissolved groundwater in some of the near-shore monitoring wells. More assessment of DNAPL and water quality in near shore sediments representing surface water is needed. Pore water and/or surface water samples will be collected in 2010 as described in the USACE (2009, April) Solid-Phase Microextraction (SPME) proposal to EPA. Sediment samples will be collected as part of the next long-term monitoring event expected to occur in 2012, or sooner.

7.4 Technical Assessment Summary

The following is a summary of technical issues regarding remedy protectiveness:

(A) Is the remedy functioning as intended by the decision documents? **No**. Cannot be determined at this time.

- Overall, the uplands remedy has been successful in preventing current human health exposures. However, DNAPL was not adequately characterized or remediated, continues to be present in the saturated zone, and may be moving into the near-shore monitoring wells, possibly indicating movement of DNAPL into Elliot Bay.
- Also, several dissolved contaminants are increasing in some of the near-shore monitoring wells, indicating the potential for discharge into Elliot Bay.
- Additional monitoring is needed to verify that uncontrolled contaminants are not reaching sediments or surface water at unacceptable concentrations.
- The sediment cap has not been completed to meet the ROD design specifications in RA5. The surface-weighted average is less than SQS. Available data from all RAs indicate sediments currently meet cleanup goals, with the exception of one station in RA5. Additional data are needed in the near-shore subtidal area due to the potential for discharge of contaminated groundwater.
- ICs for the MSU have not been implemented to restricted vessel anchorage on the cap.

(B) Are the exposure assumptions, toxicity data, cleanup levels, and remedial action objectives (RAOs) used at the time of the remedy selection still valid? **No.**

- ACLs were developed in the ROD in a manner inconsistent with CERCLA. Related assumptions were flawed and the cleanup levels based on them may not be protective of surface water and marine biota when compared to potential ARARs, and any potable groundwater (a determination that remains to be made for the site). An analysis of ARARs must be completed and revisions to ARARs and/or cleanup levels documented in a ROD amendment.
- The groundwater potability determinations and, depending on that determination, RAOs and cleanup levels, need to be revisited to ensure protectiveness.
- Vapor intrusion into a maintenance building above the cap was not evaluated and will need further analysis.

(C) Has any other information come to light that could call into question the protectiveness of the remedy? **Yes.**

- DNAPL has been detected in near-shore wells, and several contaminants seem to be increasing in the dissolved groundwater in some of the near-shore monitoring wells. More assessment of DNAPL and water quality in near shore sediments representing surface water is needed. Pore water samples will be collected in 2010 as described in the USACE 2009 SPME proposal to EPA. Sediment samples will be collected as part of the next long-term monitoring event expected to occur in 2012.

8 Issues

The following are the significant issues identified during this Five-Year Review and need to be addressed to make a protectiveness determination and contribute to long-term protectiveness of the remedy.

Issue	Affects Protectiveness (Y/N)	
	Current	Future
(1) The ROD's ACLs are not appropriate standards to demonstrate compliance and protectiveness; nonetheless, even very high concentration criteria ACLs have been exceeded in several wells. The use of ACLs and the related assumptions was flawed (see section 4.1.3) and the cleanup levels based on them are not protective of surface water and aquatic organisms when compared to likely ARARs. Potential surface-water ARARs are identified in Table 6 of Section 7.1.2 Presently, MCLs and state groundwater cleanup standards are exceeded in Site wells	Y	Y
(2) Increasing concentrations of dissolved contaminants and newly or increasingly DNAPL contaminated wells indicate possible migration seaward. However, there is no surface water quality monitoring data to assist in determining whether the UU remedy is protective of this medium. DNAPL characterization beneath the site is incomplete or inadequate, additional investigations and monitoring are needed to better define COC sources, extent, depths and architecture, fate and transport. In light of this, it is not possible to determine either current or long-term protectiveness	Y	Y
(3) There is a lack of sediment sampling in the near-shore area of RA1, RA2a, and RA3 to verify that uncontrolled contaminants are not reaching sediments at unacceptable concentrations.	Y	Y
(4) Incomplete construction of the isolation cap in RA5.	N	Y
(5) A key MSU Institutional Control (US Coast Guard restriction on anchorage) for protecting the cap has not been implemented.	N	Y
(6) Groundwater potability was not adequately evaluated in the upper or lower aquifers, although the ROD states that prospective future water supplies (potable water) are present in at least part of the site. Groundwater potability at the site must be determined.	Y	Y
(7) Vapor intrusion into the maintenance building above the UU cap was not evaluated.	Y	Y

9 Recommendations and Follow-up Actions

The following recommendations and follow-up actions are necessary to make a protectiveness determination and contribute to long-term protectiveness of the remedy.

Table 9. Recommendations and Follow-up Actions

Recommendations & Follow-up Actions [#s track to issues in Five Year Summary Review Form]	**Party Respon-sible**	**Over-sight Agency**	**Mile-stone Date**	**Follow Up Actions: Affects Protectiveness (Y/N)**	
				Current	**Future**
(1) Re-evaluate ARARs, cleanup levels and points of compliance, and assess practicability of achieving ARARs, RAOs, cleanup levels, and waiver potential for any ARAR that can't be met Make revisions, including ACL elimination, in a ROD Amendment.	EPA	EPA	2013	Y	Y
(2) (a) Additional DNAPL Characterization to better define COC sources, volume (or mass), extent, depths and architecture, and the extent of flow paths using optical screening tools with push probe insertion, e.g., TarGOST; also measure upwelling flux rates, direct-push fluorimetry, etc. (b) Collection of near-shore sediment, groundwater, surface water, and transition zone water data to measure any discharge of contaminated groundwater or NAPL. (c) Additional data collection of sediment and pore water on near-shore cap areas (RA1, RA2a, and RA2b for suspected subsurface DNAPL (RA4 is not amenable, due to rocky cap materials). Sample down to 55 ft below MLLW off the northern point. SPME locations on Figure 13 for additional pore-water collection. Dissolved phase pore water concentrations could infer the proximity of a DNAPL source and reveal whether dissolved phase COCs from DNAPL can infiltrate the sediment cap. (d) Update Conceptual Site Model with the new information and additional study results.	EPA	EPA	9/2013	Y	Y
(3) See Recommendation 2c above.	EPA	EPA	9/2013	Y	Y
(4) Add suitable dredged material to the RA5 cap to increase thickness as it becomes available	EPA	EPA	2014	N	Y

Table 9 Recommendations and Follow-up Actions (continued)

Recommendations & Follow-up Actions [#s track to issues]	Party Respon-sible	Over-sight Agency	Mile-stone Date	Follow Up Actions: Affects Protectiveness (Y/N)	
				Current	Future
(5) Implement last of ROD ICs, i.e., work with US Coast Guard to establish anchorage restrictions to protect MSU Area 6 cap.	USCG	EPA	2013	N	Y
(6) Potability Determination (a) Based on existing data and new data as necessary, determine (i) whether the formation underlying the contaminated site aquifer is a confining layer; (ii) the potability of groundwater underlying the confining layer beneath this formation; and (iii) whether upper aquifer is potable. (b) If groundwater is potable, drinking water requirements are relevant and appropriate.	EPA	EPA	2013	N	Y
(7) Groundwater/soil NAPL to indoor-air assessment for maintenance building with either groundwater data from adjacent wells/ piezometers, or near-slab subsurface data.	EPA	EPA	2010	Y	Y

10 Protectiveness Statements

10.1 Upland Unit and Groundwater Transition Zone

<u>Protectiveness deferred</u>. The remedy implemented for the Upland Unit has eliminated current human exposure; however, DNAPL was not adequately characterized or remediated, and DNAPL and dissolved DNAPL COCs in groundwater have been found in near-shore monitoring wells. A protectiveness determination given this migration of COCs from the Upland Unit cannot be made until further information is obtained, as recommended in Section 9, Recommendations for Follow-up Actions. Further information will be obtained by characterizing DNAPL in the subsurface, collecting groundwater, sediment, surface water, and pore water data, updating the conceptual site model, and re-evaluating ARARs, cleanup levels, and points of compliance. It is expected these actions will take up to 4 years to complete, at which time a protectiveness determination will be made. It is likely that some uncertainties will always remain regarding DNAPL location and potential for discharge into sediments and surface water.

10.2 Marine Sediments Unit

<u>Protectiveness deferred</u>. Sediment cap monitoring has indicated that the MSU remedy is currently meeting performance requirements and preventing exposure to contamination over the area that it was intended for. This is based on general attainment of the SQS per the MSU O&M

Monitoring Program. However, due to potential migration of DNAPL or DNAPL-contaminated groundwater, a protectiveness determination of the remedy at the MSU cannot be made until further information is obtained, as recommended in Section 9, Recommendations for follow-up actions for significant issues. Further information will be obtained by collecting groundwater, sediment, surface water and pore-water data, updating the conceptual site model, and re-evaluating ARARs, cleanup levels and points of compliance. It is expected these actions will take up to 4 years to complete, at which time a protectiveness determination will be made. It is likely that some uncertainties will always remain regarding DNAPL location and potential for discharge into sediments and surface water.

10.3 Site-wide

Protectiveness deferred. A protectiveness determination of the remedy at the Pacific Sound Resources site cannot be made until determinations are made for each of the two units as outlined in the two immediately preceding subsections.

11 Next Review

The next Five-Year Review for the PSR site is required by September 2014, five years from this review.

Figures

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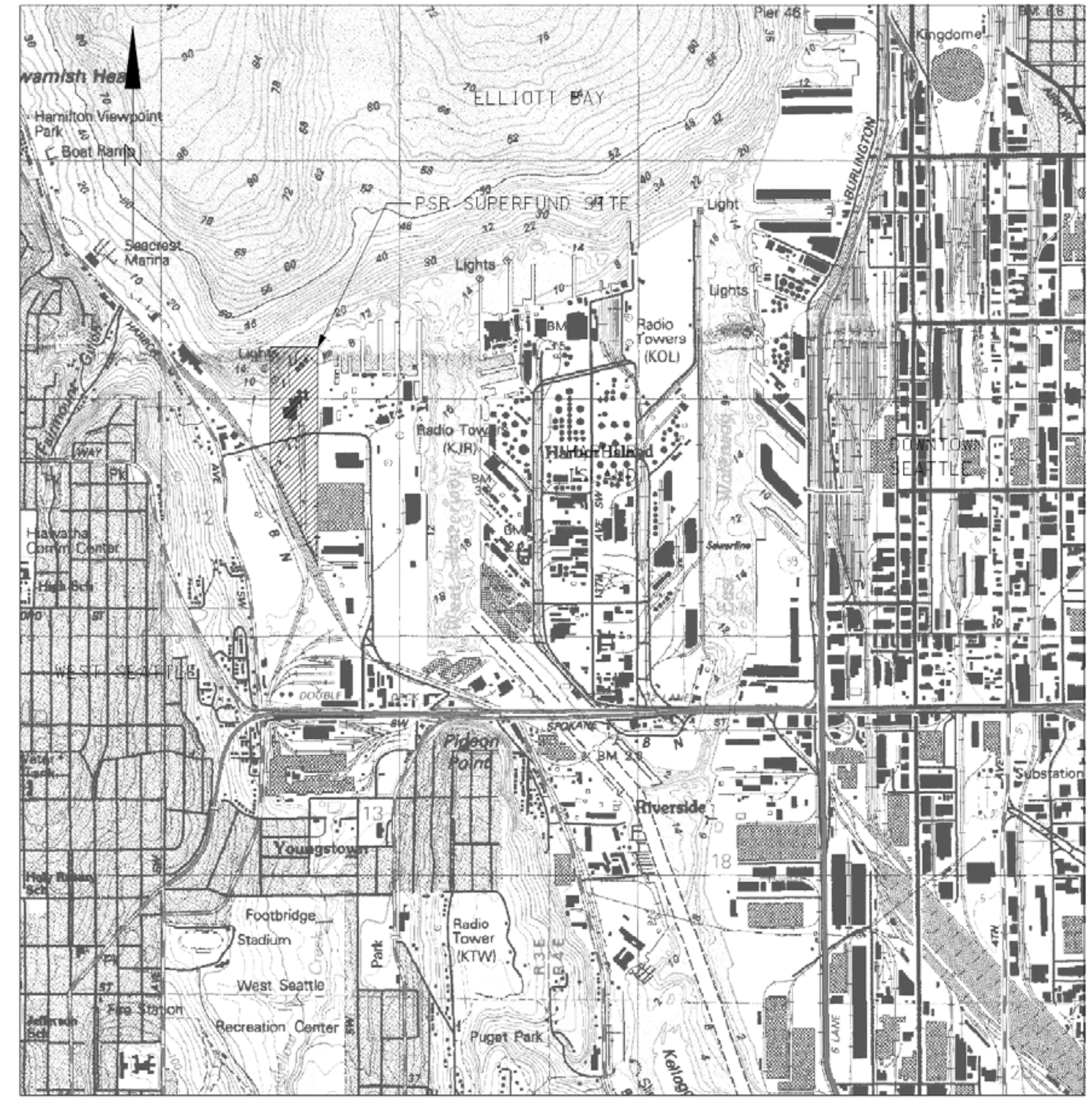
LOCATION MAP
NOT TO SCALE



VICINITY MAP
NOT TO SCALE

US Army Corps of Engineers
Seattle District

Designed by: MICHALSEN
Drawn by: BARRETT
Checked by: FISCHER
Date: 09 JAN 09

U.S. ARMY ENGINEER DISTRICT, SEATTLE
CORPS OF ENGINEERS
SEATTLE, WASHINGTON

SEATTLE DISTRICT
PORT OF SEATTLE - PSR SUPERFUND SITE
INTERIM UPLAND GW REPORT

FIGURE 1
VICINITY MAP

SEATTLE WASHINGTON

Plate number:
C-101
Sheet 2 of 4

DATE AND TIME PLOTTED: 1/14/2009 10:52:48 AM DESIGN FILE: I:\WISC\CIV\PORT OF SEATTLE\C-101 FIGURE 1.DGN

IF SHEET MEASURES LESS THAN 22" X 34" IT IS A REDUCED PRINT. REDUCE SCALE ACCORDINGLY.

Figure 1. Site Vicinity Map

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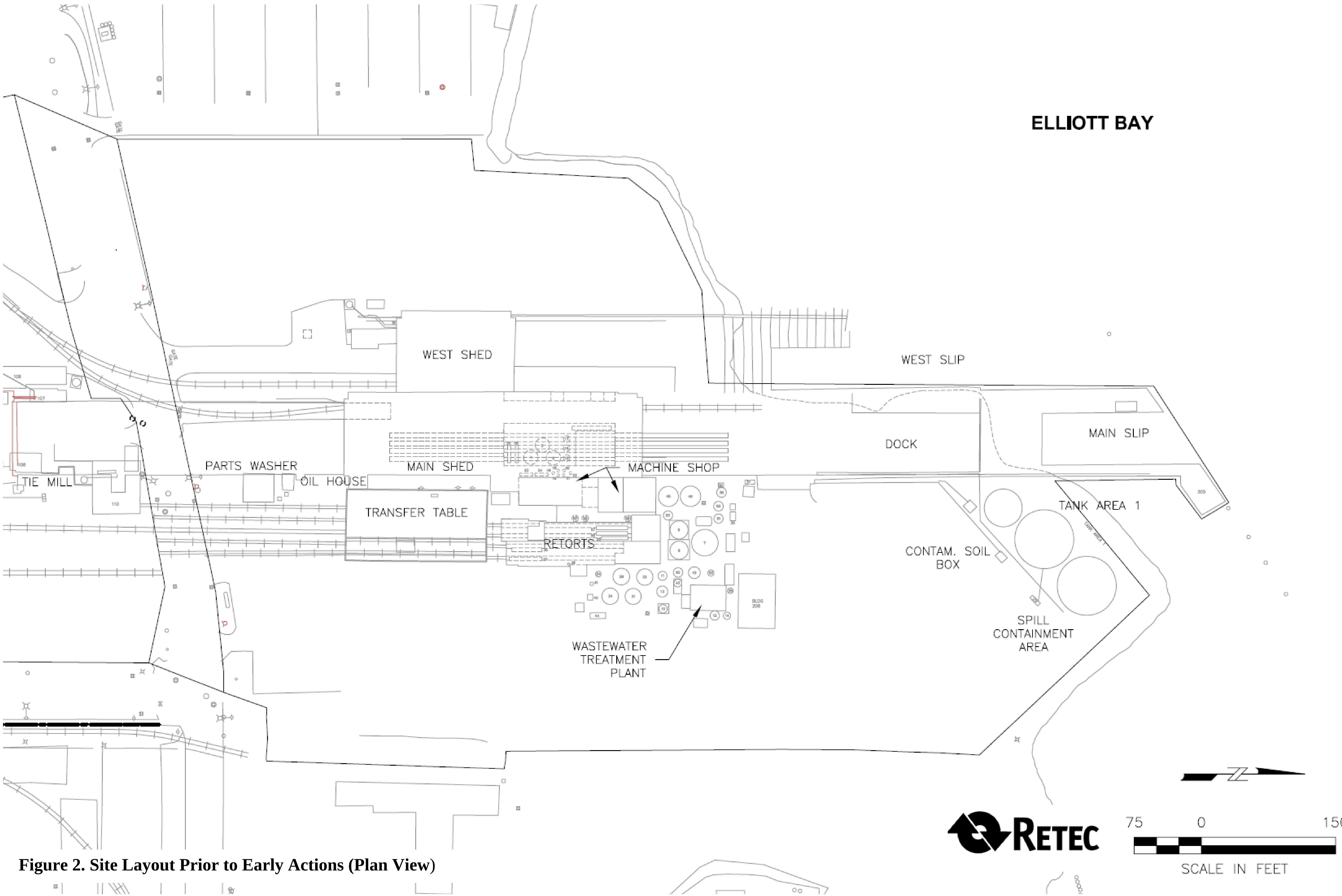

Figure 2. Site Layout Prior to Early Actions (Plan View)

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Figure 3. Site Photo During Facility Operation

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(b)(4) copyright

Figure 4. Site photo taken following early actions. Photo shows the public access park area adjacent to the shoreline and Port of Seattle Terminal 5. Note that a chain-link fence and signage prevents public access to the beach.

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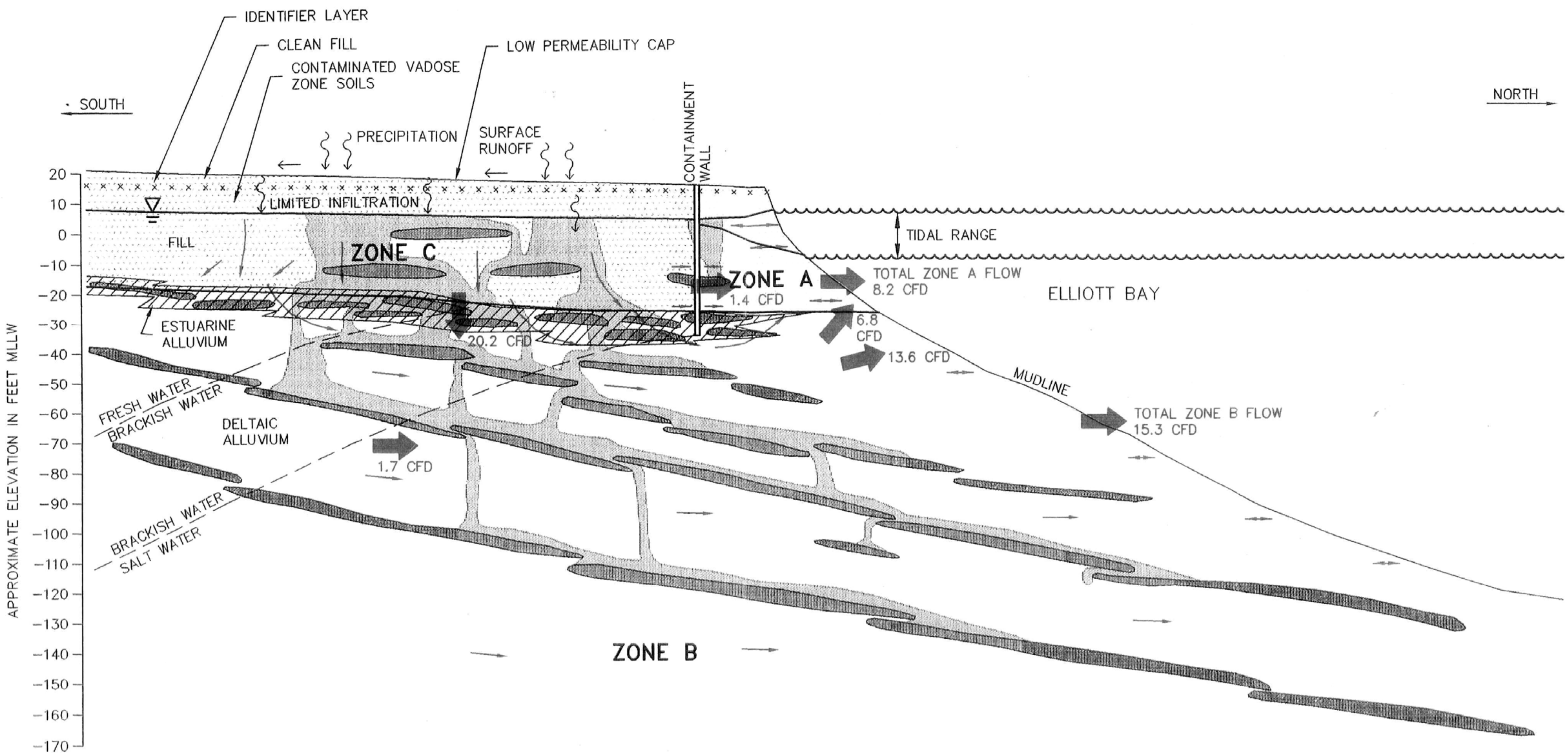

Figure 5. Conceptual Site Model (Section View)

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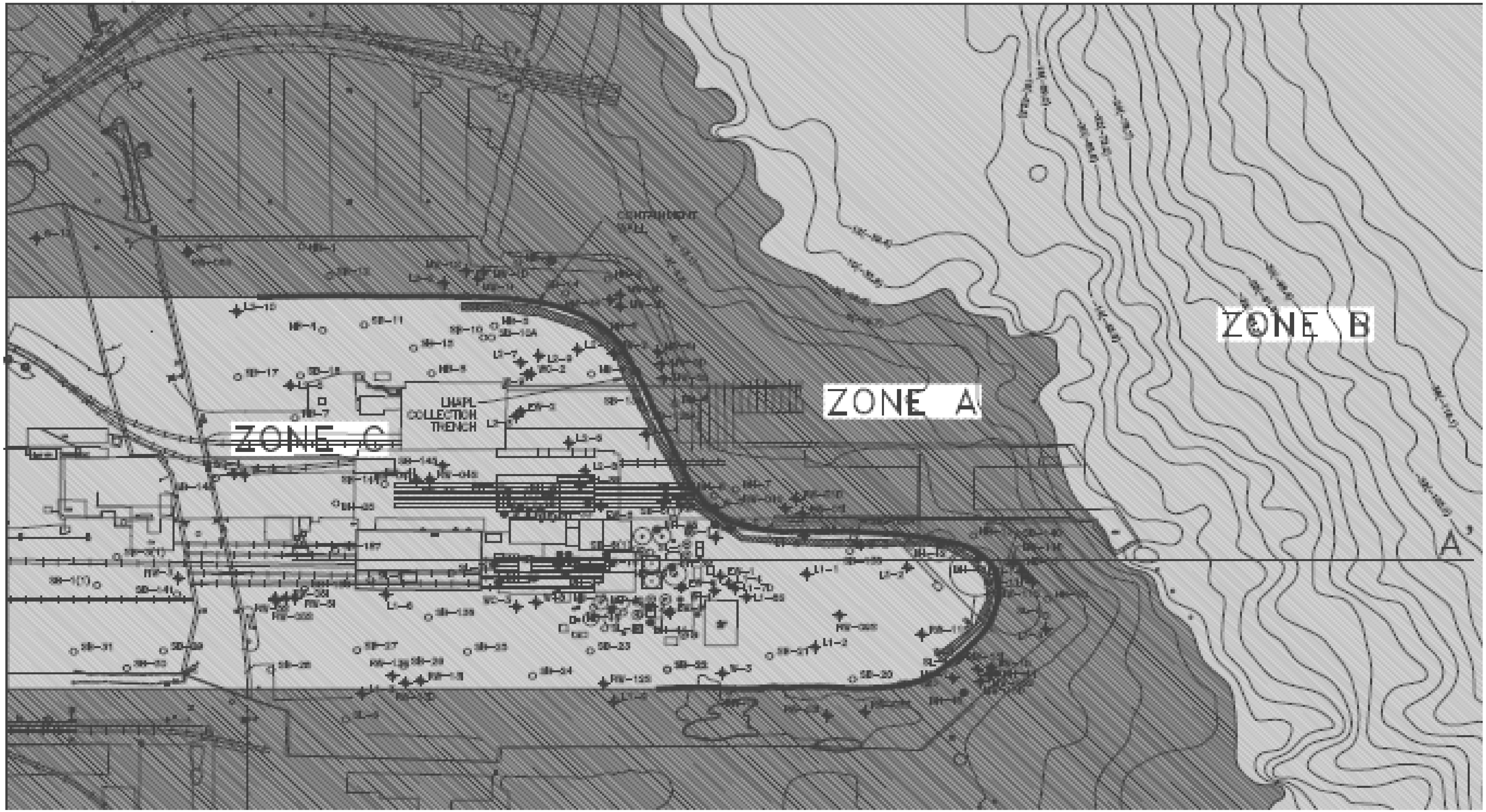

Figure 6. Plan View of Groundwater Zones. These correspond with Zones A, B, and C from Figure 5.

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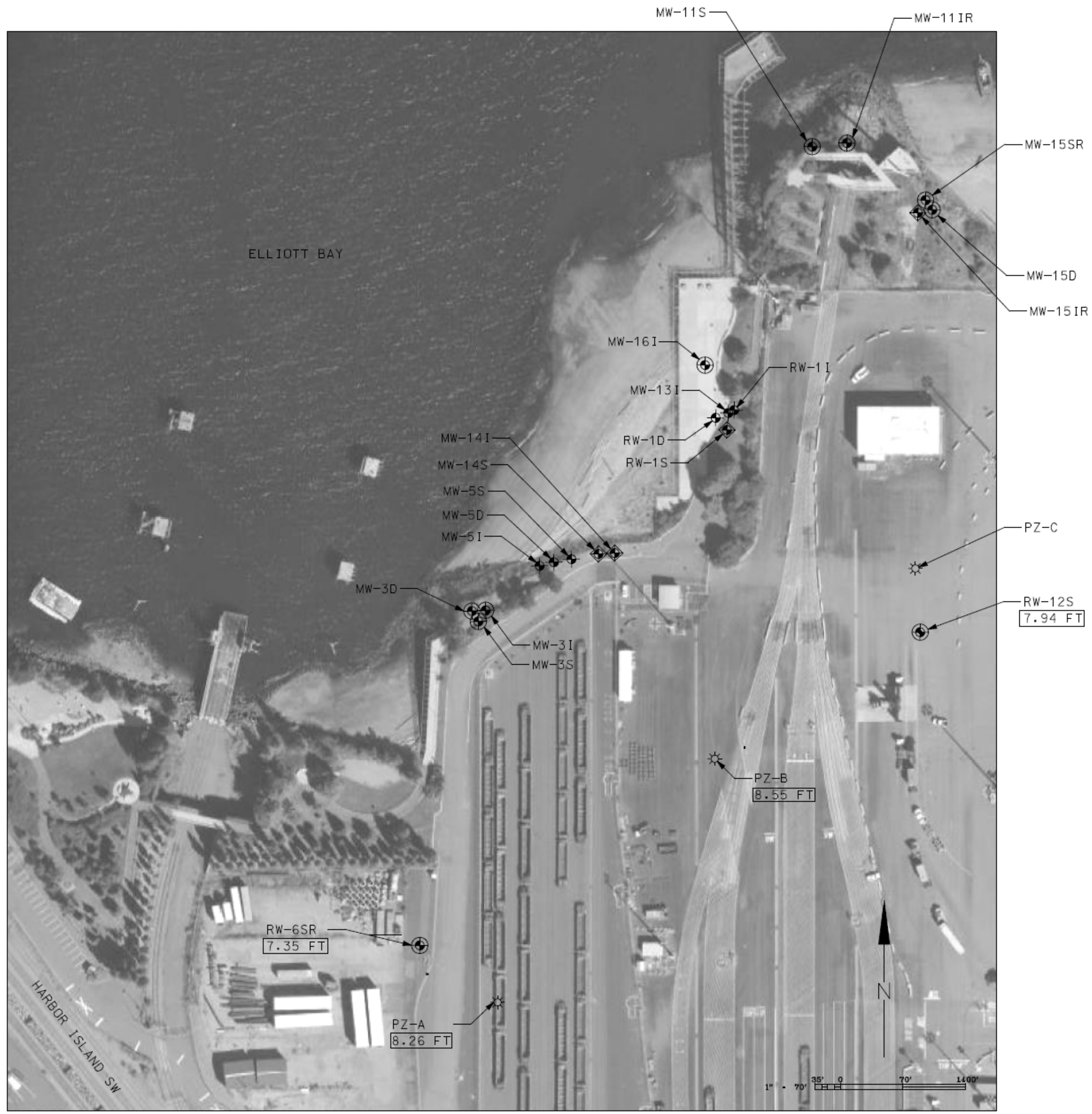

LEGEND

INTERIM GW SAMPLING LOCATIONS
INTERIM GW SAMPLING & NAPL MONITORING LOCATIONS
XXX FT GW ELEVATIONS MAESURED DURING INTERIM GW SAMPLING
MONITORING WELL LOCATION
PIEZOMETER LOCATION

US Army Corps of Engineers Seattle District

Date: 09 JAN 09
Designed by: MICHALSEN
Drawn by: BARRETT
Checked by: FISCHER
U.S.ARMY ENGINEER DISTRICT,SEATTLE CORPS OF ENGINEERS SEATTLE, WASHINGTON

SEATTLE DISTRICT
PORT OF SEATTLE - PSR SUPERFUND SITE
INTERIM UPLAND GW REPORT
FIGURE 3
SITE EXPLORATION PLAN
SEATTLE WASHINGTON

Plate number: C-103
Sheet 4 of 4

DATE AND TIME PLOTTED: 1/14/2009 10:49:53 AM DESIGN FILE: I:\MISC\CIV\PORT OF SEATTLE\C-103 FIGURE 3.DGN

IF SHEET MEASURES LESS THAN 22" X 34" IT IS A REDUCED PRINT. REDUCE SCALE ACCORDINGLY.

Figure 7. Layout of Site Monitoring Wells

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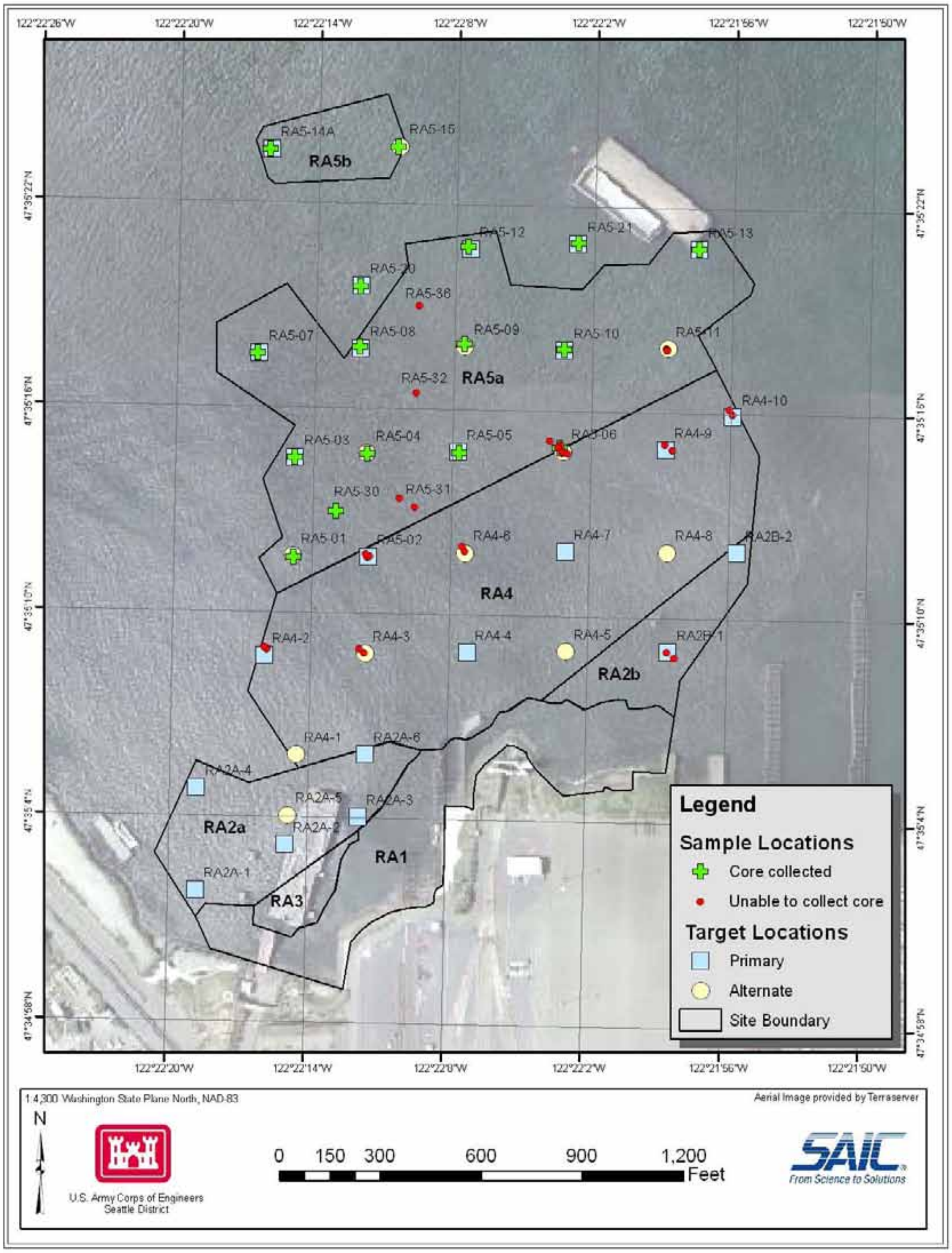

Figure 8. Sediment Locations Sampled in 2007

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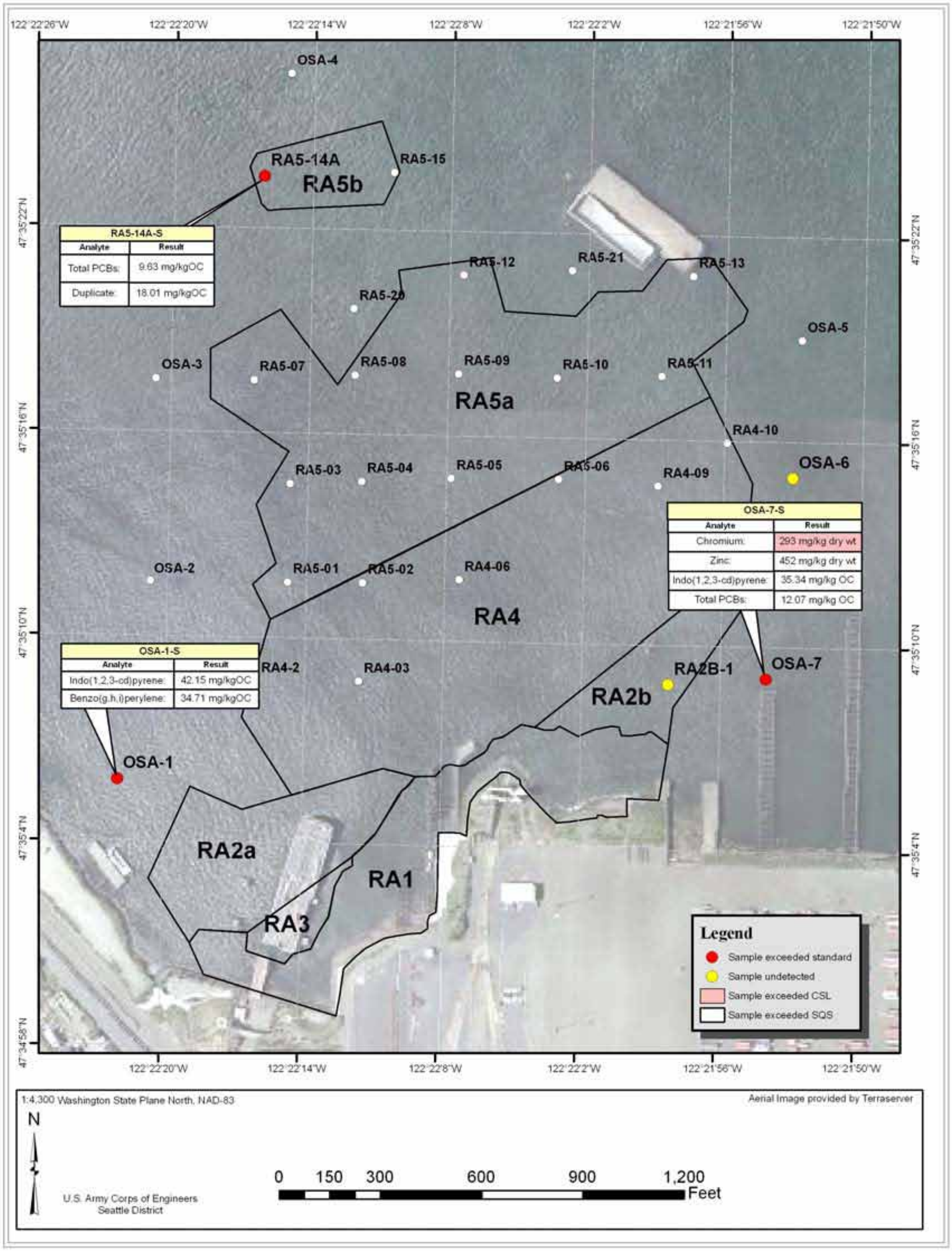

Figure 9. Chemical Results from the 2007 Cap Sampling. Only results above the Sediment Quality Standard (no highlighting) and Cleanup Screening Level (shaded) are depicted.

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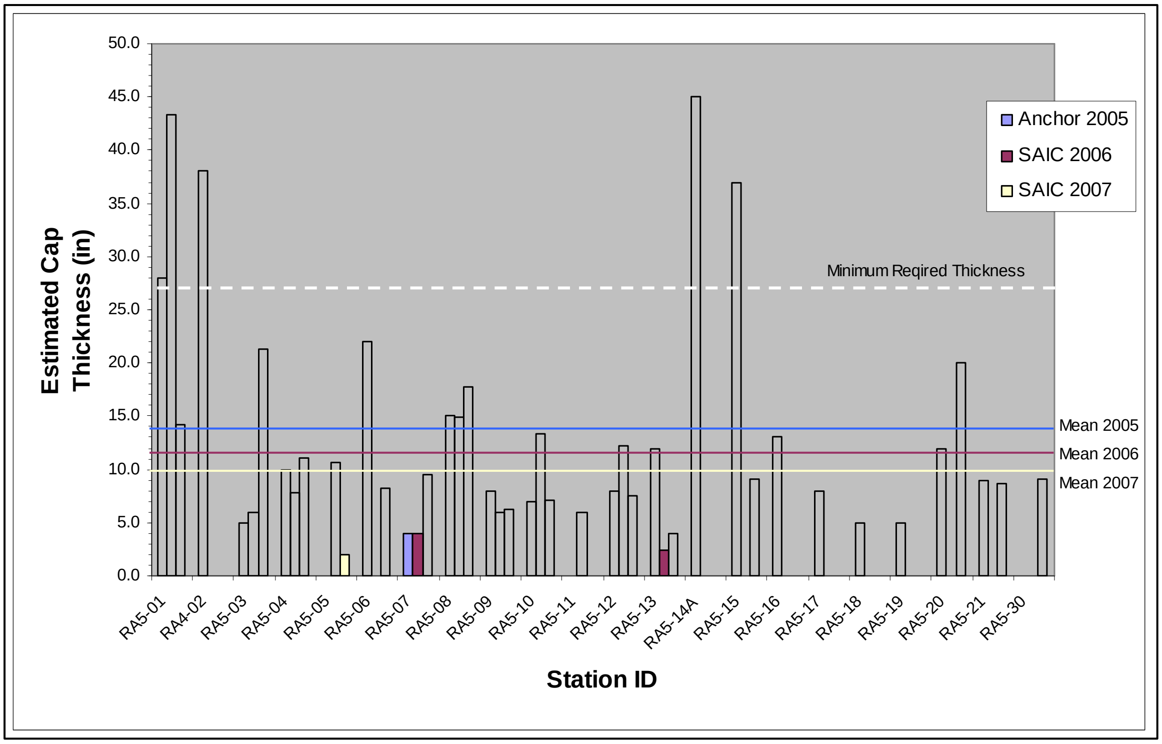

Figure 10. Cap Depth in RA5 Over 3 Sampling Events

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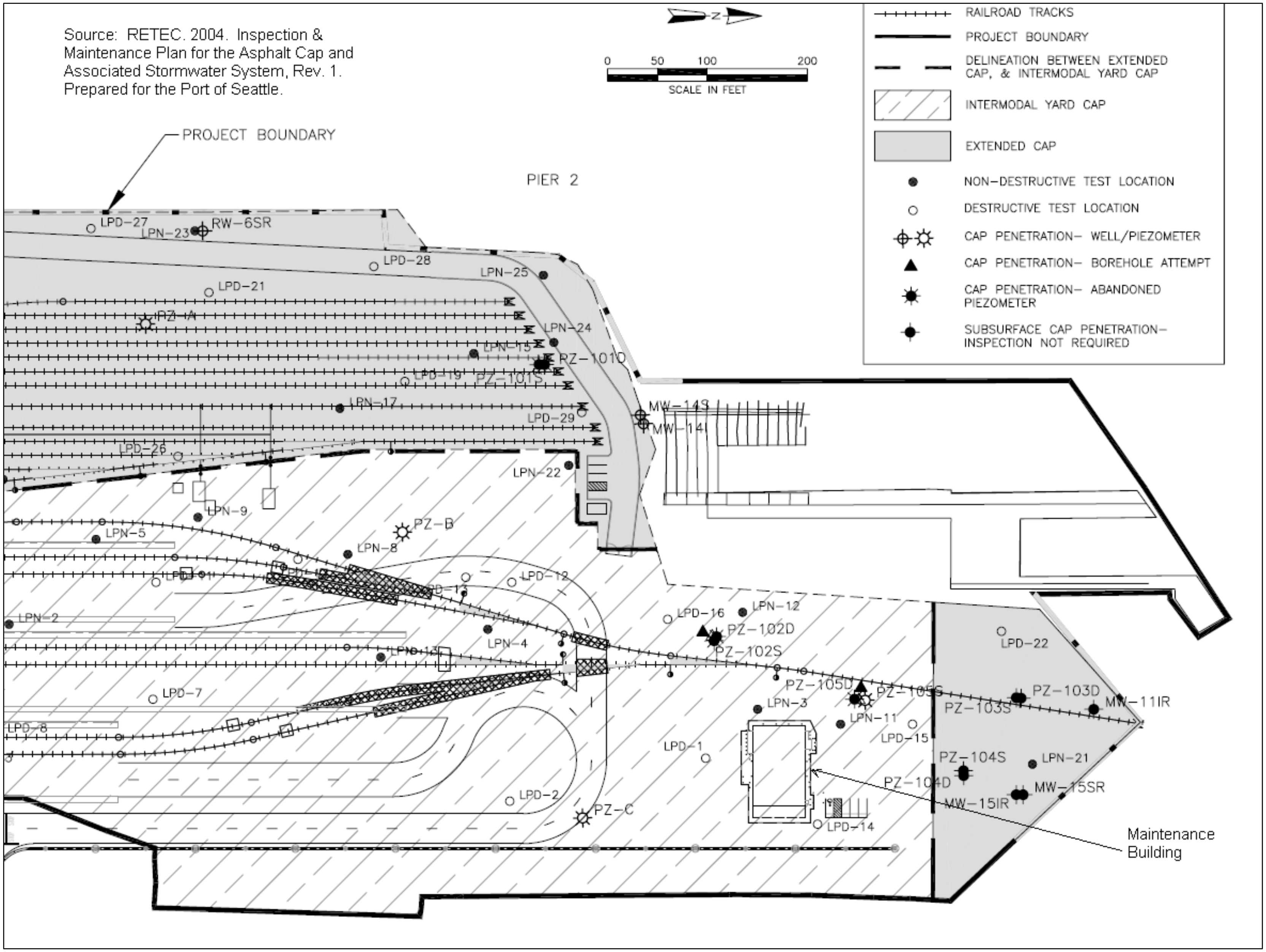

Figure 11. Location of Maintenance Building at Intermodal Yard.

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WAC 173-340-720 (2)
Ground water cleanup standards -- Non-Potable Water Defined

1a Groundwater does not serve as a current drinking water source

AND ANY OF THE FOLLOWING

1b Groundwater is not a potential drinking water source for these reasons:

- 1b(i) Well Construction IAW WAC 173-160 and Sustained Yield < 0.5 gpm
- 1b(ii) Contains Natural BG Conc of TDS 10,000 mg/L (example)
- 1b(iii) Groundwater situated at great depth or location that makes recovery for drinking technically impossible

OR

1c) A determination of Department that hazardous substances not transported away from site to source of drinking water, considering

(i) The extent of affected ground water;
(ii) The distance to existing water supply wells;
(iii) The likelihood of interconnection between the contaminated ground water and ground water that is a current or potential future source of drinking water due to well construction practices in the area of the state where the site is located;
(iv) The physical and chemical characteristics of the hazardous substance;
(v) The hydrogeologic characteristics of the site;
(vi) The presence of discontinuities in the affected geologic stratum; and
(vii) The degree of confidence in any predictive modeling performed.

OR

1d) For sites where there is an extremely low probability that the ground water will be used for that purpose because of the site's proximity to surface water that is not suitable as a domestic water supply. **An example of this situation would be shallow ground waters in close proximity to marine waters such as on Harbor Island in Seattle.** At such sites, the department may allow ground water to be classified as nonpotable for the purposes of this section if each of the following conditions can be demonstrated.

(i) The conditions specified in (a) and (c) of this subsection are met;
(ii) There are known or projected points of entry of the ground water into the surface water;
(iii) The surface water is not classified as a suitable domestic water supply source under chapter 173-201A WAC; and
(iv) The ground water is sufficiently hydraulically connected to the surface water that the ground water is not practicable to use as a drinking water source.

Figure 12. Language of Washington Administrative Code Relating to Determining Non-potability to Protect Water Supplies

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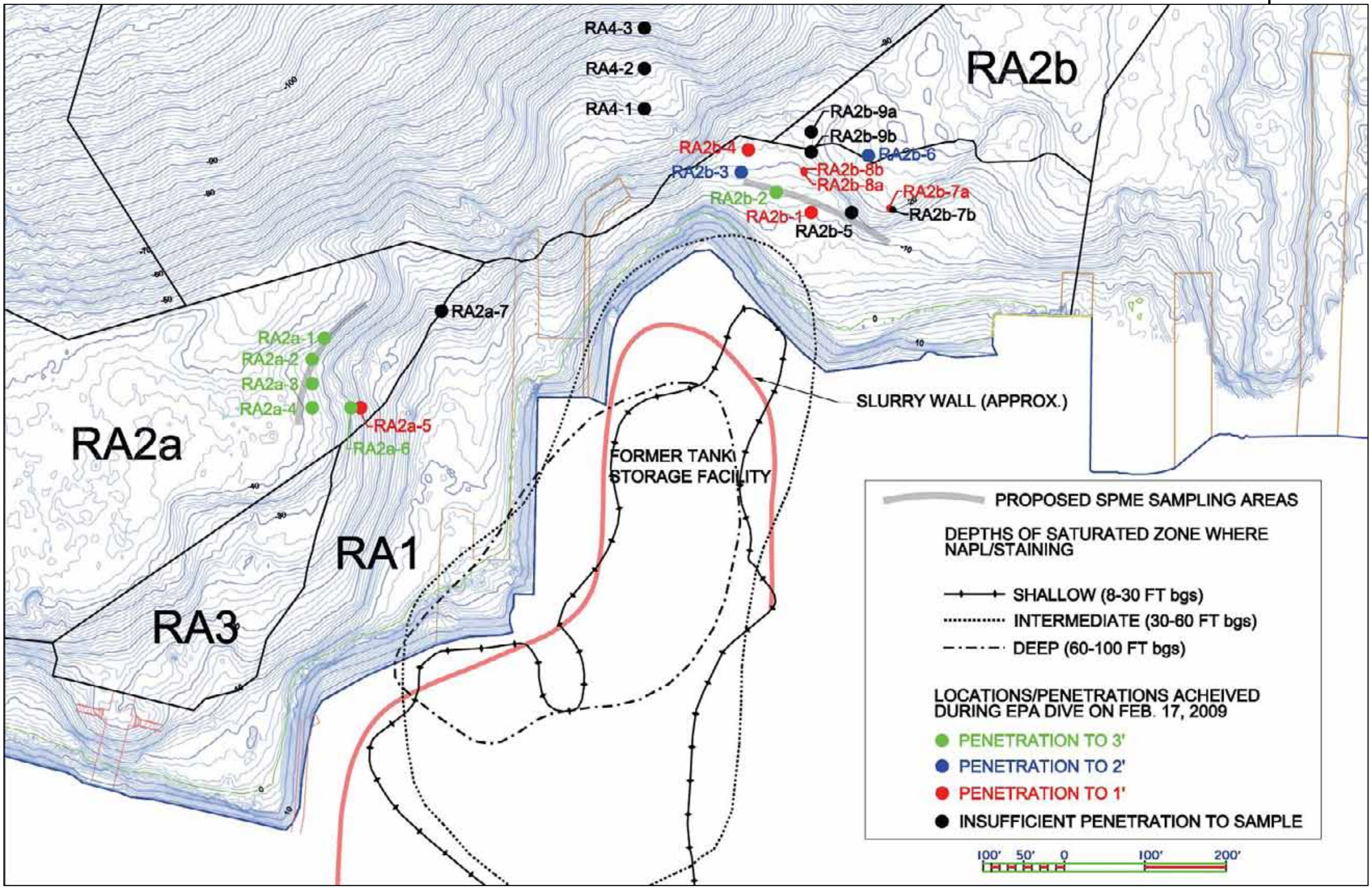

Figure 13. Plan View of Site Showing Depths and Approximate Areas of Significant Staining by DNAPL – shown as black lines at several depths. The basis for "significant staining" was 5 inches or greater of staining, so the horizontal extent into Elliott Bay may be greater than suggested. The figure also shows the depth of penetration of diver-directed probes accomplished by EPA in a 2009 survey, suggesting which areas of the cap are less amenable to penetrative investigation.

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Attachment 1

Advertisement for Notice of Five-Year Review,
Pacific Sound Resources Superfund Site

Attachment 1, Advertisement for Notice of Five-Year Review, Pacific Sound Resources Superfund Site

Comment on a Checkup on the Cleanup of the Pacific Sound Resources Site, Seattle, Washington

The U.S. Environmental Protection Agency (EPA) does regular evaluations, called five-year reviews, of certain cleanups where remaining contamination limits use of the site. We invite your comments on the second five-year review of the cleanup at the Pacific Sound Resources site on the waterfront in West Seattle. The review will check to make sure that the cleanup of the groundwater, upland area, and sediment (mud) in Elliott Bay is effective and continues to protect people and the environment.

How can I help? If you have information about problems or other comments about the site, please contact EPA's Pacific Sound Resources project manager by **December 31, 2008**:

Ravi Sanga
U.S. Environmental Protection Agency
1200 Sixth Avenue, Suite 900, ECL-111
Seattle, Washington 98101
e-mail: sanga.ravi@epa.gov
phone: 206-553-4092 or toll-free at 1-800-424-4372, extension 4092

TTY users: please call the Federal Relay Service at 1-800-877-8339 and give the operator Ravi Sanga's phone number.

What happens after the review? EPA will prepare a report that explains the results of the review. A newspaper ad will announce when the finished report is available.

Where can I get more information? More information is available at EPA's Superfund Records Center at the street address above. Call 206-553-4494 for an appointment. You can also find information on this EPA web page: **http://yosemite.epa.gov/r10/cleanup.nsf/sites/psr**

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Attachment 2

List of Documents Reviewed

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Attachment 2, List of Documents Reviewed

Anchor Environmental. 2008. Memorandum Re: Sunken Dock Site Assessment, from David Gillingham, Anchor, to Kathy Bahnic, Port of Seattle. 14 October.

CH2MHill. 2007. *Construction Report: Cap Repairs at Elliott Bay for UPRR Derailment*. Prepared by CH2MHill for Union Pacific Railroad. 21 June.

Integral Consulting. 2007. Memorandum Re: USACE Contract W912DW-06-D-1003 DO 0005 – PSR Technical Support Sunken Dock, from David Schuchardt, Integral Consulting, to Miriam Gilmer, USACE. 8 March.

Remediation Technologies, Inc., 1998. *Inspection and Maintenance Plan for the Public-Access Area at the Pacific Sound Resources Superfund Site*. Prepared for the Port of Seattle. 14 October.

RETEC Group. 2004. *Inspection and Maintenance Plan for the Asphalt Cap and Associated Stormwater System*. Revision 1. Prepared for the Port of Seattle. 27 January.

_____. 2004. *Upland Groundwater Remedy Confirmational Monitoring Plan*. Prepared for the Port of Seattle. 5 March.

_____. 2004. *Upland Groundwater Remedy Sampling and Analysis Plan.* Prepared for the Port of Seattle. 1 March.

URS Corpporation. 2002. *Conceptual Site Design. PSR Superfund Site MSU*, Technical Memorandum #2. Seattle, WA. 12 June.

U.S. Environmental Protection Agency. 1999. *PSR Superfund Site Record of Decision*. USEPA Region 10, Seattle, Washington. 20 September.

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Attachment 3

Data Quality Review

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Pacific Sound Resources

Five Year Review
Chemical Data Quality
Technical Memorandum

U.S. Army Corps of Engineers
Seattle District

20 December 2008

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Pacific Sound Resources Superfund Site

Five-Year Review

Chemical Data Quality Technical Memorandum

1.0 Introduction

This *Chemical Data Quality Technical Memorandum* is a component of the Five-Year Review (5YR), and provides an assessment of the data collected for the rounds of groundwater sampling that have been accomplished by RETEC/AECOM for the Port of Seattle and, more recently, by USACE Seattle District.

Five years of long-term monitoring data are being reviewed to address questions regarding the adequacy of the remedy. The points of comparison for the remedy are the ROD criteria and modified PRGs described in the *Risk Assessment Technical Memorandum*. The adequacy of the analytical results in supporting these criteria are assessed in terms measurement performance criteria (Section 2).

The quality of the data for decision making has been assessed for the sampling events in 2003, 2004, 2005, 2006 and 2008. This technical memorandum summarizes the findings of those data assessments and focuses on key data usability elements for the 5YR as described below.

The scope of the data quality assessment is determined in part by the known and reasonably anticipated comparisons for which the data might be used. ROD performance standards exist for the groundwater to surface water pathway, but not for groundwater as a pathway of exposure via drinking or bathing. This is because the ROD determined that the aquifers subtending the site are non-potable, Potability of groundwater in Washington is procedurally defined in Section 173-340-720(2) of the Washington Administrative Code (WAC).. Although PSR groundwater was designated as non-potable by Ecology prior to the ROD, Ecology may not have followed the cited WAC in making this determination. No specific 720(2) criteria were cited, and there is a lack of information regarding adjacent aqujifer potability. The WAC cited requires consideration of potential contaminant migration to other aquifers that are potential future water supplies. Although a portion of PSR groundwater (shallow and nearest the shoreline) is saline due to tidal influence and therefore not potable, portions further from the shoreline and/or at greater depth may be sufficiently free from tidal influence as to be potable. While drinking water standards would not become Relevant and Appropriate Requirements unless EPA decided to open or modify the ROD, they have been included for comparison in this chemical data quality review. Similarly, although preliminary remediation goals (PRGs) are not legally binding and not performance standards, they are included to inform possible future risk-protectiveness of there remedy for adjacent aquifers.

2.0 Data Assessment Criteria

Data quality is based on measurement performance criteria which relate to the parameters of precision, accuracy/bias, representativeness, comparability, completeness and sensitivity (quantitation limits). The parameters are indicators of the qualitative and quantitative data quality measurements and, hence, are referred to as data quality indicators (DQIs).

2.1 Precision and Comparability

Precision is defined as the degree of mutual agreement among independent measurements as the result of repeated application of the same process under similar conditions. Analytical precision is evaluated via the relative percent difference (RPD) values of laboratory control sample/laboratory control sample duplicate (LCS/LCSD), matrix spike/matrix spike duplicate (MS/MSD), and duplicate sample (inorganic only) analyses. The RPD values of field duplicate analyses represent the combined precision of sample collection and analysis procedures, as well as sample homogeneity.

Precision is calculated as follows:

$$\textit{Relative Percent Difference (RPD)} = 100\% \times \left|\frac{x_1 - x_2}{(x_1 + x_2)/2}\right|$$

where:
x_1 = *original sample concentration*
x_2 = *duplicate sample concentration*

$$\textit{Relative Percent Difference (RPD)} = 100\% \times \left|\frac{x_1 - x_2}{(x_1 + x_2)/2}\right|$$

where:
x_1 = *original sample concentration*
x_2 = *duplicate sample concentration*

In EPA (1992), outside-control limit recoveries in duplicate spiked samples indicates data should be considered as an estimate (J) with a low or high bias. Duplicate samples with RPDs within control limits are considered *comparable* (see Section 2.5). These data may be usable as estimates, depending upon the extent of exceedance of the limits. The data may be less useful for comparing samples as for trends. (See comparability.)

2.2 Accuracy/Bias

Accuracy is the degree of agreement between an observed value (sample result) and an accepted reference value; *bias* describes the systematic or persistent distortion associated with a measurement process. The terms accuracy and bias are used interchangeably in this document. The project team should determine and document the following:

- Quantitative measurement performance criteria for acceptable accuracy/bias for each matrix, analytical group, and concentration level.
- Analyte-specific measurement performance criteria, if applicable.
- QA/QC activities, or QC samples, that should be performed or analyzed to measure accuracy/bias for each matrix, analytical group, and concentration level.

Analyte accuracy/bias can be evaluated using different types of QC samples. For example, a standard reference material or a laboratory control sample (LCS) that contains a known concentration of analyte(s) spiked into contaminant-free water or other blank matrix provides information about how accurately the laboratory (analysts, equipment, reagents, etc.) can analyze for a specific analyte(s) using a selected method. Single-blind and double-blind proficiency testing (PT) samples also provide information on how accurately the laboratory can analyze for a specific analyte using a selected method. The cumulative laboratory and method accuracy/bias is calculated as a percentage using the following equation:

$$\text{Accuracy} = \frac{\text{Measured Value}}{\text{True Value}} \times 100\%$$

$$\text{Accuracy} = \frac{\text{Measured Value}}{\text{True Value}} \times 100\%$$

Because environmental samples contain interferences (i.e., other compounds that may interfere with the analysis of a specific analyte), the accuracy/bias for a specific analyte should be evaluated in relation to the sample matrix. This is done by analyzing matrix spike samples. A known concentration of the analyte is added to an aliquot of the sample. The difference between the concentration of the analyte in the unspiked sample and the concentration of the analyte in the spiked sample should be equal to the concentration of the analyte that was spiked into the sample. The spike recovery is calculated as a percentage using the following equation:

$$\text{Percent Recovery} = \frac{\text{(Spiked Sample Conc.} - \text{Unspiked Sample Conc.)}}{\text{Spiked Conc. Added}} \times 100\%$$

Frequently, matrix spike samples are prepared and analyzed in duplicate, especially for organic analyses, to provide sufficient precision and accuracy data to evaluate achievement of project quality objectives. Analytical accuracy is evaluated via the percent recovery (%R) values of initial and continuing calibration (percent difference or percent drift [%D] for organic analyses), internal standards, surrogate spikes (organic analyses only), MS/MSD, LCS/LCSD, in conjunction with method blank, calibration blank, equipment rinsate blank, and trip blank results. Results of blanks assist in identifying the type and magnitude of effects contributed to the system error introduced via field and/or laboratory procedures.

2.3 Representativeness

Representativeness is a qualitative term that describes the extent to which a sampling design adequately reflects the environmental conditions of a site. It takes into consideration the magnitude of the site area represented by one sample and indicates the feasibility and reasonableness of that design rationale. Representativeness also reflects the ability of the sample team to collect samples and the ability of the laboratory personnel to analyze those samples so that the generated data accurately and precisely reflect site conditions. In other words, a discrete sample that is collected and then subsampled by the laboratory is representative when its measured contaminant concentration equates to the contaminant concentration of some predefined vertical and horizontal spatial area at the site. Sample homogeneity, and sampling and subsampling variability, should be considered when developing criteria for representativeness. The use of statistical sampling designs and standardized SOPs for sample collection and analysis help to ensure that samples are representative of site conditions.

The following criteria are documented in the QAPP:

- Qualitative measurement performance criteria for acceptable representativeness for each matrix, analytical group, and concentration level.
- Analyte-specific measurement performance criteria, if applicable.
- QA/QC activities, or QC samples, that should be performed or analyzed to measure representativeness for each matrix, analytical group, and concentration level.

2.4 Completeness

Completeness is a measure of the amount of valid data collected using a measurement system. It is expressed as a percentage of the number of measurements that are specified in the QAPP.

Completeness is defined as follows:

$\text{Data Completeness} = \dfrac{\text{number of usable results}}{\text{number of samples planned}}$
$\text{Data Completeness} = \dfrac{\text{number of usable results}}{\text{number of samples planned}}$

Usable data are defined as data reported by the laboratory and were not determined rejected, with or without data qualifiers including UJ, U, and J as assigned via the data validation. Samples failed the receiving criteria (broken or lost) are considered unusable.

EPA (1992) emphasizes that 100% of *critical samples* be complete. If critical samples are not defined, then meeting the QAPP-stated control limits determines the completeness. The primary issue is loss of confidence level and power of the sampling if data are incomplete.

2.5 Comparability

Comparability is the degree to which different methods or data agree or can be represented as similar. It describes the confidence that two data sets can contribute to a common analysis and interpolation.

The QAPP documents the following comparability criteria:

- Quantitative performance criteria for acceptable data comparability for each matrix, analytical group, and concentration level.
- Analyte-specific measurement performance criteria, if applicable.
- QA/QC activities, or QC samples, that should be performed or analyzed to measure data comparability for each matrix, analytical group, and concentration level.

For example, to ensure data comparability for repeated monitoring well sampling, SOPs should require that well casings be notched or permanently marked so that the water level measurement is taken from the same spot for each sampling event.

EPA (1992) targets similar methods with similar preparation methods and detection limits for permitting unfettered use of data for risk assessment. When some pairs of data are not comparable, it suggests that those pairs not be used for risk assessment and that estimates be redirected to the remaining comparable data.

2.6 Sensitivity

Sensitivity depicts the ability an analytical system (i.e., sample preparation and instrumental analysis) to detect a target component in a given sample matrix with a defined level of confidence. To evaluate if the analytical sensitivity achieved the project expectation, sample-specific practical quantitation limits (PQLs) are compared against the project-specific reporting limits (RL) goals set forth in the QAPP. In addition, sample results were compared to detections of target analytes in method blanks to identify potential effects of laboratory background.

3.0 Data Assessment

3.1 2003 Sampling Data

Groundwater monitoring events occurred in May and August 2003. Laboratory results ware reviewed to determine if the data was usable. Results indicate that the data is acceptable as discussed in the data validation reports (Appendix A).

Groundwater Sample ID	Sample Date	Sample Time	Laboratory ID	PAHs	Total Zinc	PCP	Dibenzofurans
SDG K2303887							
RW-1S-0503	5/23/2003	15:00	K2303887-001	X	X	X	X
MW-3S-0503		08:50	K2303887-002	X	X	X	X
MW-3I-0503		09:25	K2303887-003	X	X	X	X
MW-5S-0503		12:10	K2303887-004	X	X	X	X
MW-11S-0503	5/24/2003	10:00	K2303887-005	X	X	X	X
MW-131-0503	5/23/2003	15:40	K2303887-006	X	X	X	X
MW-14S-0503		13:00	K2303887-007	X	X	X	X
MW-14I-0503		13:40	K2303887-008	X	X	X	X
MW-105S-0503		10:00	K2303887-009	X	X	X	X
MW-15-SR-0503	5/24/2003	10:45	K2303887-010	X	X	X	X
MW-15-IR-0503		11:20	K2303887-011	X	X	X	X
SDG K2303940							
MW-6SR-0503	5/28/2003	17:00	K2303940-001	X	X	X	X
MW-12S-0503		16:00	K2303940-002	X	X	X	X
SDG K2306931							
MW-11S-0903	9/9/2003	13:16	K2306931-001	X	X	X	X
MW-11IR·-903		12:00	K2306931-002	X	X	X	X
RW·12S·0903		11 :00	K2306931-003	X	X	X	X
MW·15IR·0903		14:49	K2306931-004	X	X	X	X
MW·15SR·0903		15:40	K2306931-005	X	X	X	X
RW·1S·0903	9/8/2003	16:20	K2306931-006	X	X	X	X
MW·14S-0903		14:55	K2306931-007	X	X	X	X
RW-6SR-0903		10:30	K2306931-008	X	X	X	X
MW-3S-0903		12:10	K2306931-009	X	X	X	X
MW-31-0903		13:00	K2306931-010	X	X	X	X
MW-141-0903		13:45	K2306931-011	X	X	X	X
MW-114-0903		13:45	K2306931-012	X	X	X	X
Method Key: PAHs, PCP, dibenzofuran (8270C SIM); total zinc (6010B)							

3.1.1 Data Quality Indicators

3.1.1.1 Precision

<u>K2303887 and K230940</u>

The RPDs for the duplicates were within the 0-30% QC limits for water samples at 0.0-10.9%, or RPDs were not applicable due to results that were undetected in both samples. Only reportable data points were considered when evaluating RPDs. Although some reportable data require qualification based on field duplicate RPDs, overall field and laboratory precision is acceptable since a majority of the data is unqualified.

K2306931

The RPDs for the duplicates were within the 0-30% QC limits for water samples at 0.0-25.0%, or RPDs were not applicable due to results that were undetected in both samples, results that were within +/- the MRL. Only reportable data points were considered when evaluating RPDs. Some reportable data require qualification based on surrogate or LCS recoveries, overall field and laboratory accuracy is acceptable since a majority of the data is unqualified, and overall analytical system accuracy is demonstrated.

3.1.1.2 Accuracy

K2303887 and K230940

Field accuracy, a measure of sampling bias, was not determined for this sampling round since field blank, equipment rinsate blank, and/or trip blank samples were not applicable to the requested analyses or sampling methods, or were not submitted for analysis. All laboratory %Rs were compared to EPA published or laboratory control chart limits. Although some reportable data require qualification based on surrogate or LCS recoveries, overall field and laboratory accuracy is acceptable.

K2306931

Although some reportable data require qualification based on LCS/LCSD or MS/MSD recoveries, overall laboratory accuracy is acceptable since a majority of the data is unqualified, and overall analytical system accuracy is demonstrated.

3.1.1.3 Representativeness

K2303887, K230940, K2306931

All field samples were collected using the same sampling techniques. No field work variances or other anomalies in protocol were notes. Therefore, samples are considered representative of native groundwater conditions.

3.1.1.4 Completeness

K2303887, K230940 and K2306931

All of the data reported were usable, some with qualification. Since no data were missing or rejected, completeness of the data set was calculated to be 100% and is acceptable.

3.1.1.5 Comparability

<u>K2303887, K2303940 and K2306931</u>

All data was generated by EPA SW-846 analytical methods appropriate to the analytes of concern. The method control criteria and QA/QC procedures set forth in the project-specific QAPP were consistently applied. Therefore, the data can be confidently represented as comparable.

3.1.1.6 Sensitivity

<u>K2303887 and K2303940:</u>

The method reporting limits (MRLs) are achievable by the quoted methods. Some samples required dilution due high target analyte concentration, high non-target analyte concentration, or matrix interference. The reporting limits for diluted results were raised appropriately.

Method 8270C SIM - The laboratory appropriately reanalyzed at dilution initial sample results that exceeded instrument calibration range. The sample concentrations that exceeded instrument calibration range require J qualifiers to indicate estimated concentrations that cannot be accurately quantitated. These results are identified as "Do Not Report' in the validator qualifiers field of the EDD, and should not be considered when reviewing site sample data since alternate,
acceptable results from secondary dilution analyses are provided.

All Methods - Sample results reported at concentrations greater than or equal to the method detection limit (MDL) but less than the MRL require J qualifiers to indicate estimated concentrations.

<u>K2306931:</u>

Comments: The method reporting limits (MRLs) are achievable by the quoted methods. Some samples required dilution due high target analyte concentration, high non-target analyte concentration, or matrix interference. The reporting limits for diluted results were raised appropriately.

Method 8270C SIM - The laboratory appropriately reanalyzed at dilution initial sample results that exceeded instrument calibration range. The sample concentrations that exceeded instrument calibration range require J qualifiers to indicate estimated concentrations that cannot be accurately quantitated. These results are identified as "Do Not Report” in the validator qualifiers field of the EDD, and should not be considered when reviewing site sample data since alternate,
acceptable results from secondary dilution analyses are provided.

All Methods- Sample results reported at concentrations greater than or equal to the method detection limit (MDL) but less than the MRL require J qualifiers to indicate estimated concentrations.

3.1.1.7 Comparison to Existing ARARs and Proposed Action Levels

COCs exceeding ACLs, PRGs or MCLs or with reporting limits above those value may not be protective. These COCs include the following:

- Benzo(a)anthracene ≥PRG in MW-15SR, RW-12S, MW-14S, RW-1S, MW-11IR, RW-1S, MW-11IR, MW-15IR, MW-14I
- Benzo(a)anthracene RL≥PRG in
- Benzo(a)pyrene ≥PRG in MW-11S, MW-15SR, RW-6SR, RW-12S, MW-14S, RW-1S, MW-3I, MW-11IR, MW-15IR
- Benzo(a)pyrene RL≥PRG in MW-11S, RW-6SR, RW-12S, MW-3I
- Benzo(a)pyrene ≥PRG, MCL in MW-11IR, MW-15IR, MW-14I
- Benzo(a)pyrene RL≥PRG, MCL in MW-11I, MW-15SR , MW-14S, RW-1S, MW-15I, MW-14I
- Benzo(b)fluoranthene ≥PRG in MW-11S, MW-15SR, RW-6SR, RW-12S, MW-14S, MW-3I, RW-1S, MW-11IR, MW-15IR, MW-14I
- Benzo(b)fluoranthene RL≥PRG in MW-11S, RW-6SR, MW-11I
- Benzo(k)fluoranthene ≥PRG in MW-15SR, MW-14S, RW-1S, MW-11IR, MW-15IR, MW-15IR, MW-14I
- Benzo(k)fluoranthene RL≥PRG in RW-6SR
- Chrysene ≥PRG in MW-11I, MW-15SR, MW-14S, RW-1S, MW-11IR, MW-15IR, MW-14I
- Dibenz(a,h)anthracene ≥PRG in MW-15SR, RW-6SR, RW-1S, MW-11IR, MW-3I, MW-14I, MW-31S, MW-11IR, MW-15IR, MW-14I
- Dibenz(a,h)anthracene RL≥PRG in MW-15SR, MW-14S, MW-3I, MW-15IR
- Dibenzofuran ≥ACL in MW-15I, MW-14I
- lndeno(1 ,2.3-cd)pyrene RL≥ACL in MW-15IR
- lndeno(1,2.3-cd)pyrene ≥PRG in MW-15SR, RW-12S, MW-14S, RW-1S, MW-11IR, MW-15IR, MW-14I
- lndeno(1,2.3-cd)pyrene RL≥PRG in RW-6SR, MW-3I, MW-15IR
- lndeno(1,2.3-cd)pyrene ≥ACL, PRG, MCL in MW-14I, MW-15IR
- Naphthalene ≥ACL in MW-15IR
- Naphthalene ≥ACL, PRG in MW-15IR
- Naphthalene ≥PRG in MW-15SR, RW-12S, MW-14S, RW-1S, MW-11IR, MW-14I
- Naphthalene ≥PRG in RW-1S
- Pentachlorophenol RL≥PRG in MW-11S, RW-6SR, MW-15IR
- Pentachlorophenol ≥PRG, MCL in MW-15SR, RW-1S, MW-15IR
- Pentachlorophenol RL ≥PRG, MCL in MW-15SR, MW-14S, MW-15IR
- Pentachlorophenol RL ≥ACL, PRG, MCL in RW-6SR MW-14I
- Phenanthrene ≥PRG, MCL in RW-1S

3.2 2004 Sampling Data

The 2004 groundwater monitoring events occurred in February, May, August and November. Laboratory results ware reviewed to determine if the data was usable. Results indicate that the data is acceptable as discussed in the data validation reports (Appendix B).

Groundwater Sample ID	Sample Date	Sample Time	Laboratory ID	PAHs	Total Zinc	PCP	Dibenzofurans
SDG K2401405							
MW-11S-0204	2/24/2004	16:58	K2401405-001	X	X	X	X
MW-11IR-0204	2/25/2004	9:40	K2401405-002	X	X	X	X
MW-15SR-0204		12:35	K2401405-003	X	X	X	X
MW-15IR-0204		11 :45	K2401405-004	X	X	X	X
RW-6SR-0204		14:20	K2401405-005	X	X	X	X
RW-12S-0204		10:40	K2401405-006	X	X	X	X
MW-14I-0204		15:20	K2401405-007	X	X	X	X
MW-14S-0204		16:35	K2401405-008	X	X	X	X
Duplicate-0204		16:35	K2401405-009	X	X	X	X
MW-31-0204	2/26/2004	10:20	K2401405-010	X	X	X	X
MW-3S-0204		9:05	K2401405-011	X	X	X	X
RW-1S-0204		11 :18	K2401405-012	X	X	X	X
SDG K2403767							
MW-31-0504	05/20/2004	13:00	K2403767-001	X	X	X	X
MW-3S-0504		12:10	K2403767-002	X	X	X	X
RW-6SR-0504		15:10	K2403767-003	X	X	X	X
RW-1S-0504		11:00	K2403767-004	X	X	X	X
MW-111R-054	05/19/2004	11:45	K2403767-005	X	X	X	X
MW-11S-0504		13:10	K2403767-006	X	X	X	X
MW-14I-0504	05/20/2004	14:25	K2403767-007	X	X	X	X
MW-14S-1104		13:50	K2403767-008	X	X	X	X
MW-15IR-1104	05/19/2004	14:45	K2403767-009	X	X	X	X
MW-15SR-1104		14:00	K2403767-010	X	X	X	X
RW-100S0504	05/20/2004	10:00	K2403767-011	X	X	X	X
RW-12S054		16:10	K2403767-012	X	X	X	X
SDG K2406237							
MW-3S-0804	8/17/2004	16:35	K2406237-001	X	X	X	X
MW-31-0804		15:57	K2406237-202	X	X	X	X
MW-11 S-0804	8/16/2004	16:03	K2406237-003	X	X	X	X
MW 111R 0804		15.03	K2406237-004	X	X	X	X
MW-15SR-0804		13:50	K2406237-005	X	X	X	X
MW-151R-0804		12:56	K2406237-006	X	X	X	X
RW-6SR-0804	8/17/2004	18:03	K2406237-007	X	X	X	X
RW-12S-0804		09:12	K2406237-008	X	X	X	X
RW-1S-0804		1123	K2406237-009	X	X	X	X
MW-131-0804		1040	K2406237-010	X	X	X	X
MW-14S-0804		14:42	K2406237-011	X	X	X	X
MW-141-0804		13:58	K2406237-012	X	X	X	X
MW-30S-0804		16:35	K2406237-013	X	X	X	X

Groundwater Sample ID	Sample Date	Sample Time	Laboratory ID	PAHs	Total Zinc	PCP	Dibenzofurans
SDG K2409373							
MW-3S-1104	11/22/2004	15:14	K2409373-001	X	X	X	X
MW-3I-1104		14.28	K2409373-002	X	X	X	X
MW-11S-1104	11/23/2004	16:21	K2409373-003	X	X	X	X
MW-11IR-1404		15:36	K2409373-004	X	X	X	X
MW-14S-1104	11/22/2004	12:28	K2409373-005	X	X	X	X
MW-14I-1104		11:08	K2409373-006	X	X	X	X
MW-15SR-1104	11/23/2004	14:23	K2409373-007	X	X	X	X
MW-15IR-1104		13:37	K2409373-008	X	X	X	X
RW-1S-1104		16:53	K2409373-009	X	X	X	X
RW-1I-1104		10:24	K2409373-010	X	X	X	X
RW-6SR-1104	11/22/2004	09:19	K2409373-011	X	X	X	X
MW-04S-1104		13:28	K2409373-012	X	X	X	X
RW-12S-1104	11/23/2004	17:30	K2409373-013	X	X	X	X
Method Key: PAHs, PCP, dibenzofuran (8270C SIM); total zinc (6010B)							

3.2.1 Data Quality Indicators

3.2.1.1 Precision

K2401405

The RPDs for the duplicates were within the 0-30% QC limits for water samples at 0.0-24.4%. No data required qualification based on measurements of laboratory precision. All precision measurements were acceptable.

K2403767

Not applicable - field duplicate samples were not submitted with this data set. Field precision/comparability could not be evaluated..

K2406237

The field duplicate RPDs were within the 0-30% water QC limits, or RPDs were not applicable due to results that were undetected in both samples, or results that were within +/- the reporting limit, except as identified below.

- Naphthalene RPD = 62.3% U/J for samples MW-3S-0804 (0.078U) and MW-30S-0804 (0.15).

Field duplicate and native sample concentrations that were both undetected are not applicable. Although some data require qualification based on field duplicate RPDs, overall field and laboratory precision is acceptable since a majority of the data is unqualified and no data are rejected.

K2409373

Not applicable - field duplicate samples were not submitted with this data set. Field precision/comparability could not be evaluated.

3.2.1.2 Accuracy

K2403767

Although some data require qualification based on surrogate %Rs, overall laboratory accuracy is acceptable since a majority of the data is unqualified, and since most outliers stem from suspected matrix interference and not analytical error.

K2401405

Although some reportable data require qualification based on trip blank contamination or matrix spike %Rs ,overall laboratory accuracy is acceptable since a majority of the data is unqualified and no data are rejected.

K2406237

None of the reportable results required qualification based on accuracy measurements, and overall laboratory accuracy is acceptable.

K2409373

Although some reportable data require qualification based on surrogate recovery overall laboratory accuracy is acceptable since a majority of the data is unqualified and no data are rejected.

3.2.1.3 Representativeness

K2401405, K2403767, K2406237, K2409373

All field samples were collected using the same sampling techniques. No field work variances or other anomalies in protocol were notes. Therefore, samples are considered representative of native groundwater conditions.

3.2.1.4 Completeness

K2401405, K2403767, K2406237 and K2409373

All of the data reported were usable, some with qualification. Since no data were missing or rejected, completeness of the data set was calculated to be 100% and is acceptable.

3.2.1.5 Comparability

K2401405, K2401405, K2403767, K2406237, K2409373

All data was generated by EPA SW-846 analytical methods appropriate to the analytes of concern. The method control criteria and QA/QC procedures set forth in the project-specific QAPP were consistently applied. Therefore, the data can be confidently represented as comparable.

3.2.1.6 Sensitivity

K2401405

The method reporting limits (MRLs) are achievable by the quoted methods Some samples required dilution due to high target analyte concentration or matrix Interference. The reporting limits for diluted results were raised appropriately.

All Methods - Sample results reported at concentrations greater than or equal to the method detection limit (MDL) but less than the MRL require J qualifiers to indicate estimated concentrations. The analyte cannot be accurately quantitated at this concentration level.

Method 8270 SIM - The laboratory appropriately reanalyzed at dilution Initial sample results that exceeded instrument calibration range. The sample concentrations that exceeded instrument calibration range were designated as not reportable (DNR qualified) in the project EDD file since alternative, more accurate results were provided for the analyte.

<u>K2403767</u>

The method reporting limits (MRLs) are achievable by the quoted methods Some samples required dilution due to high target analyte concentration or matrix Interference. The reporting limits for diluted results were raised appropriately.

All Methods - Sample results reported at concentrations greater than or equal to the method detection limit (MDL) but less than the MRL require J qualifiers to indicate estimated concentrations. The analyte cannot be accurately quantitated at this concentration level.

Method 8270 SIM - The laboratory appropriately reanalyzed at dilution Initial sample results that exceeded instrument calibration range. The sample concentrations that exceeded instrument calibration range were designated as not reportable (DNR qualified) in the project EDD file since alternative, more accurate results were provided for the analyte.

<u>K2406237</u>

The method reporting limits (MRLs) are achievable by the quoted methods Some samples required dilution due to high target analyte concentration or matrix Interference. The reporting limits for diluted results were raised appropriately.

All Methods - Sample results reported at concentrations greater than or equal to the method detection limit (MDL) but less than the MRL require J qualifiers to indicate estimated concentrations. The analyte cannot be accurately quantitated at this concentration level.

Method 8270 SIM - The laboratory appropriately reanalyzed at dilution Initial sample results that exceeded instrument calibration range. The sample concentrations that exceeded instrument calibration range were designated as not reportable (DNR qualified) in the project EDD file since alternative, more accurate results were provided for the analyte.

<u>K2409373</u>

The method reporting limits (MRLs) are achievable by the quoted methods. Some samples required dilution due to high target analyte concentration or matrix Interference. The reporting limits for diluted results were raised appropriately.

All Methods - Sample results reported at concentrations greater than or equal to the method detection limit (MDL) but less than the MRL require J qualifiers to indicate estimated concentrations. The analyte cannot be accurately quantitated at this concentration level.

Method 8270 SIM - The laboratory appropriately reanalyzed at dilution Initial sample results that exceeded instrument calibration range. The sample concentrations that exceeded instrument calibration range were designated as not reportable (DNR qualified) in the project EDD file since alternative, more accurate results were provided for the analyte.

3.2.1.7 Comparison to Existing ARARs and Proposed Action Levels

COCs exceeding ACLs, PRGs or MCLs or with reporting limits above those value may not be protective. These COCs include the following:

- Acenaphthene ≥PRG in MW-14S
- Benzo(a)anthracene ≥PRG in MW-15SR, RW-12S, MW-14S, RW-1S, MW-11IR, MW-15IR, MW-14I
- Benzo(a)pyrene ≥PRG in MW-3S, MW-11S, MW-15SR, RW-6SR, RW-12S, MW-14S, RW-1S, MW-11IR, MW-15IR, MW-14I
- Benzo(a)pyrene RL≥PRG in MW-3S, MW-11S, RW-6SR, RW-12S, MW-3I
- Benzo(a)pyrene ≥PRG, MCL in MW-14S, RW-1S, MW-3I, MW-15IR, MW-14I
- Benzo(a)pyrene RL≥PRG, MCL in MW-15IR
- Benzo(b)fluoranthene ≥PRG in MW-3S, RW-12S, MW-14S, RW-1S, MW-3I, MW-11IR, MW-15IR, MW-14I
- Benzo(b)fluoranthene RL≥PRG in MW-3S, MW-3I
- Benzo(k)fluoranthene ≥PRG in MW-15SR, MW-14S, RW-1S, MW-15IR, MW-14I
- Benzo(k)fluoranthene RL≥PRG in MW-15IR
- Chrysene ≥ACL in MW-14I
- Chrysene ≥PRG in MW-15SR, MW-14S, RW-1S, MW-11IR, MW-15IR, MW-14I
- Chrysene RL≥PRG in
- Dibenz(a,h)anthracene ≥PRG in MW-14S, RW-1S, MW-3I, MW-11IR, MW-15IR, MW-14I
- Dibenz(a,h)anthracene RL≥PRG in MW-3S, RW-12S, MW-14S, MW-3I, MW-11IR, MW-14I
- Dibenzofuran ≥ACL in MW-14I
- lndeno(1,2.3-cd)pyrene ≥ACL in MW-15IR
- lndeno(1,2.3-cd)pyrene RL≥ACL in MW-15IR
- lndeno(1,2.3-cd)pyrene ≥PRG in MW-3S, MW-15SR, RW-12S, MW-14S, RW-1S, MW-3I, MW-11IR, MW-15IR, MW-14I
- lndeno(1,2.3-cd)pyrene RL≥PRG in MW-3S, RW-12S, MW-3I
- lndeno(1,2.3-cd)pyrene ≥ACL, PRG in MW-14I
- lndeno(1,2.3-cd)pyrene RL≥ACL, PRG in MW-14I
- Naphthalene ≥ACL in MW-15IR
- Naphthalene ≥ACL, PRG in MW-14I
- Naphthalene ≥PRG in MW-14S, RW-1S, MW-11IR, MW-14I Naphthalene RL≥PRG in MW-15IR
- Naphthalene ≥PRG, MCL in RW-12S, MW-15IR
- Pentachlorophenol ≥PRG in MW-3S
- Pentachlorophenol RL≥PRG in MW-3S, MW-11S
- Pentachlorophenol ≥PRG, MCL in MW-15SR, MW-14S, RW-1S, MW-3I, MW-11IR, MW-14I

3.3 2005 and 2006 Sampling Data

The 2005/2006 groundwater monitoring events occurred in February, May, August, December 2005 and February 2006. Laboratory results ware reviewed to determine if the data was usable. Results indicate that the data is acceptable as discussed in the data validation reports (Appendix C).

Groundwater Sample ID	Sample Date	Sample Time	Laboratory ID	PAHs	Total Zinc	PCP	Dibenzofurans
SDG K2501404							
RW-1S-0205	2/24/2005	16:50	K2501404-001	X	X	X	X
RW-12S-0205		15:50	K2501404-002	X	X	X	X
MW-15IR-0205		14:40	K2501404-003		X	X	X
MW-11S-0205		12:00	K2501404-004	X	X	X	X
MW-15SR-0205	2/23/2005	17:25	K2501404-005	X	X	X	X
MW-14I-0205		16:05	K2501404-006	X	X	X	X
MW-14S-0205		15:30	K2501404-007	X	X	X	X
MW-31-0205		14:20	K2501404-008	X	X	X	X
MW-3S-0205		13:30	K2501404-009	X	X	X	X
RW-6SR-0205		12:10	K2501404-010	X	X	X	X
RW-16SR-0205 RW-6SR-0205		12:10	K2501404-011	X	X	X	X
MW-11IR-0205		10:00	K2501404-012	X	X	X	X
SDG K0500631							
RW-6SR-0505	5/26/2005	14:25	K0500631-001	X	X	X	X
MW-3S-0505		16:40	K0500631-002	X	X	X	X
MW3I-0505		17:53	K0500631-003	X	X	X	X
MW-14S-0505		18:48	K0500631-004	X	X	X	X
MW-14I-0505	5/27/2005	09:53	K0500631-005	X	X	X	X
RW-1S-0505		10:58	K0500631-006	X	X	X	X
MW-15IR-0505		12:37	K0500631-007	X	X	X	X
MW-15SR-0505		13:28	K0500631-008	X	X	X	X
MW-11S-0505		14:46	K0500631-009	X	X	X	X
MW-11IR-0505		15:27	K0500631-010	X	X	X	X
RW-12S-0505		16:30	K0500631-011	X	X	X	X
RW-2S-0505		16:30	K0500631-012	X	X	X	X
TB		11:59	K0500631-013	X	X	X	X

Groundwater Sample ID	Sample Date	Sample Time	Laboratory ID	PAHs	Total Zinc	PCP	Dibenzofurans
SDG K0503447							
RW-1S-0805	8/26/2005	15:55	K0503447-001	X	X	X	X
MW-3I-0805		15:02	K0503447-002	X	X	X	X
MW-3S-0805		15:10	K0503447-003	X	X	X	X
RW-6SR-0805		13:30	K0503447-004	X	X	X	X
MW-11IR-0805		09:58	K0503447-005	X	X	X	X
MW-11S-0805		10:25	K0503447-006	X	X	X	X
RW-12S-0805	8/25/2005	10:30	K0503447-007	X	X	X	X
MW-14I-0805		13:15	K0503447-008	X	X	X	X
MW-14S-0805		11:55	K0503447-009	X	X	X	X
MW-15IR-0805	8/26/2005	11:50	K0503447-010	X	X	X	X
MW-15SR-0805		11:57	K0503447-011	X	X	X	X
MW-21-0805 MW-11IR-0805		10:15	K0503447-012	X	X	X	X
SDG K0506546							
RW-1S-1205	12/7/2005	12:04	K0506546-001	X	X	X	X
MW-16I-1205		13:30	K0506546-002	X	X	X	X
MW-14S-1205		14:40	K0506546-003	X	X	X	X
M1-14I-1205		15:30	K0506546-004	X	X	X	X
MW-3S-1205		16:52	K0506546-005	X	X	X	X
MW-3I-1205		17:50	K0506546-006	X	X	X	X
MW-11R-1205	12/8/2005	10:45	K0506546-007	X	X	X	X
MW-11S-1205		12:00	K0506546-008	X	X	X	X
MW-15IR-1205		15:05	K0506546-009	X	X	X	X
MW-15SR-1205		16:00	K0506546-010	X	X	X	X
RW-12S-1205		17:06	K0506546-011	X	X	X	X
RW-6SR-1205		18:30	K0506546-012	X	X	X	X
SDG K0601586							
MW-15SR-0206	2/28/2006	14:25	K0601586-001	X	X	X	X
MW-3S-0206	2/27/2006	10:35	K0601586-002	X	X	X	X
M2-14S-0206		12:20	K0601586-003	X	X	X	X
MW-3I-0206		13:28	K0601586-004	X	X	X	X
MW-14I-0206		14:55	K0601586-005	X	X	X	X
MW-11IR-0206		16:12	K0601586-006	X	X	X	X
MW-11S-0206		17:40	K0601586-007	X	X	X	X
MW-1S-0206		10:18	K0601586-008	X	X	X	X
RW-6SR-0206		09:20	K0601586-009	X	X	X	X
MW-16I-0206		11:18	K0601586-010	X	X	X	X
MW-16IR-0206		11:18	K0601586-011	X	X	X	X
MW-12S-0206		12:55	K0601586-012	X	X	X	X
MW-15IR-0206	2/28/2006	14:05	K0601586-013	X	X	X	X

Method Key:
PAHs, PCP, dibenzofuran (8270C SIM); total zinc (6010B)

3.3.1 Data Quality Indicators

3.3.1.1 Precision

K2501404

The field duplicate RPDs were within the 0-30% water QC limits, or RPDs were not applicable due to results that were within +/- the reporting limit, or were undetected in both samples. No data require qualification based on these measurements, and overall laboratory precision is acceptable.

K0500631

The field duplicate RPDs were within the 0-30% water QC limits, or RPDs were not applicable due to results that were within +/- the reporting limit, or were undetected in both samples. No data require qualification based on these measurements, and overall laboratory precision is acceptable.

K0503447

The field duplicate RPDs were within the 0-30% water QC limits, or RPDs were not applicable due to results that were undetected in both samples. No data require qualification based on these measurements, and overall laboratory precision is acceptable.

K0506546

Not applicable – field duplicate samples were not submitted for analysis. Filed precision/comparability was not evaluated.

K0601586

The field duplicate RPDs were within the 0-30% water QC limits, or RPDs were not applicable due to results that were undetected in both samples. No data require qualification based on these measurements, and overall field and laboratory precision is acceptable.

3.3.1.2 Accuracy

K2501404

Although some reportable data require qualification based on trip blank contamination or matrix spike %Rs, overall laboratory accuracy is acceptable since a majority of the data is unqualified and no data are rejected.

K0500631

Although some reportable data require qualification based on trip blank contamination or matrix spike %Rs, overall laboratory accuracy is acceptable since a majority of the data is unqualified and no data are rejected.

K0503447

Although some reportable data require qualification based on trip blank contamination or matrix spike %Rs, overall laboratory accuracy is acceptable since a majority of the data is unqualified and no data are rejected.

K0506546

Although some reportable data require qualification based on trip blank contamination or matrix spike %Rs, overall laboratory accuracy is acceptable since a majority of the data is unqualified and no data are rejected.

K0601586

Although some reportable data require qualification based on trip blank contamination or matrix spike %Rs, overall laboratory accuracy is acceptable since a majority of the data is unqualified and no data are rejected.

3.3.1.3 Representativeness

K2501404, K0500631, K0503447, K0506546, K0601586

All field samples were collected using the same sampling techniques. No field work variances or other anomalies in protocol were notes. Therefore, samples are considered representative of native groundwater conditions.

3.3.1.4 Completeness

K2501404

All of the reportable data so determined are usable, some with qualification. Since no data were missing or rejected, completeness of the data set was calculated to be 100% and is acceptable.

K0500631

All of the reportable data so determined were usable, some with qualification. Since alternate acceptable results existed for those analytes that exceeded instrument calibration range or were associated with internal standard area outliers, no data were missing or rejected. Completeness of the data set was calculated to be 100% and is acceptable.

K0503447

All of the reportable data so determined were usable, some with qualification. Since alternate acceptable results existed for those analytes that exceeded instrument calibration range or were associated with internal standard area outliers, no data were missing or rejected. Completeness of the data set was calculated to be 100% and is acceptable.

K0506546

All of the reportable data so determined were usable, some with qualification. Since alternate acceptable results existed for those analytes that exceeded instrument calibration range or were associated with internal standard area outliers, no data were missing or rejected. Completeness of the data set was calculated to be 100% and is acceptable.

K0601586

All of the reportable data so determined were usable, some with qualification. Since alternate acceptable results existed for those analytes that exceeded instrument calibration range or were associated with internal standard failure, no data were missing or rejected. Completeness of the data set was calculated to be 100% and is acceptable.

3.3.1.5 Comparability

K2501404, K0500631, K0503447, K0506546, K0601586

All data was generated by EPA SW-846 analytical methods appropriate to the analytes of concern. The method control criteria and QA/QC procedures set forth in the project-specific QAPP were consistently applied. Therefore, the data can be confidently represented as comparable.

3.3.1.6 Sensitivity

K2501404

The method reporting limits (MRLs) are achievable by the quoted methods. Some samples required dilution due to high target analyte concentration. The reporting limits for diluted results were raised appropriately.

All Methods - Sample results reported at concentrations greater than or equal to the method detection limit (MDL) but less than the MRL require J qualifiers to indicate estimated concentrations. The analyte cannot be accurately quantitated at this concentration level.

Method 8270C SIM - The laboratory appropriately reanalyzed at dilution initial sample results that exceeded instrument calibration range. The sample concentrations that exceeded instrument calibration range were designated as not reportable (DNR qualifier) in the project EDD file since alternative, more accurate results were provided for the analyte.

<u>K0500631</u>

The method reporting limits (MRLs) are achievable by the quoted methods. Some samples required dilution due to high target analyte concentration. The reporting limits for diluted results were raised appropriately.

All Methods - Sample results reported at concentrations greater than or equal to the method detection limit (MDL) but less than the MRL require J qualifiers to indicate estimated concentrations. The analyte cannot be accurately quantitated at this concentration level.

Method 8270C SIM - The laboratory appropriately reanalyzed at dilution initial sample results that exceeded instrument calibration range. The sample concentrations that exceeded instrument calibration range were designated as not reportable (DNR qualifier) in the project EDD file since alternative, more accurate results were provided for the analyte.

<u>K0503447</u>

The method reporting limits (MRLs) are achievable by the quoted methods. Some samples required dilution due to high target analyte concentration. The reporting limits for diluted results were raised appropriately.

All Methods - Sample results reported at concentrations greater than or equal to the method detection limit (MDL) but less than the MRL require J qualifiers to indicate estimated concentrations. The analyte cannot be accurately quantitated at this concentration level. (Note that an MDL for the method 6010B analysis was not provided in either the laboratory report or the EDD file.)

Method 8270C SIM - The laboratory appropriately reanalyzed at dilution initial sample results that exceeded instrument calibration range. The sample concentrations that exceeded instrument calibration range were designated as not reportable (DNR qualifier) in the project EDO file since alternative, more accurate results were provided for the analyte.

For samples analyzed at multiple dilution levels, reported positive concentrations were compared between runs for similarity in concentration. As a conservative approach, unqualified positive concentrations reported above the MRL were identified as the reportable results over undetected results for same target analytes regardless of dilution level.

K0506546

The method reporting limits (MRLs) are achievable by the quoted methods. Some samples required dilution due to high target analyte concentration. The reporting limits for diluted results were raised appropriately.

All Methods - Sample results reported at concentrations greater than or equal to the method detection limit (MDL) but less than the MRL require J qualifiers to indicate estimated concentrations. The analyte cannot be accurately quantitated at this concentration level. (Note that an MDL for the method 6010B analysis was not provided in either the laboratory report or the EDD file.)

Method 8270C SIM - The laboratory appropriately reanalyzed at dilution initial sample results that exceeded instrument calibration range. The sample concentrations that exceeded instrument calibration range were designated as not reportable (DNR qualifier) in the project EDD file since alternative, more accurate results were provided for the analyte.

For samples analyzed at multiple dilution levels, reported positive concentrations were compared between runs for similarity in concentration. As a conservative approach, unqualified positive concentrations reported above the MRL were identified as the reportable results over undetected results for same target analytes regardless of dilution level.

K0601586

The method reporting limits (MRLs) are achievable by the quoted methods. Some samples required dilution due to high target analyte concentration. The reporting limits for diluted results were raised appropriately.

All Methods - Sample results reported at concentrations greater than or equal to the method detection limit (MDL) but less than the MRL require J qualifiers to indicate estimated concentrations. The analyte cannot be accurately quantitated at this concentration level.

Method 8270C SIM - The laboratory appropriately reanalyzed at dilution initial sample results that exceeded instrument calibration range. The sample concentrations that exceeded instrument calibration range were designated as not reportable (DNR qualifier) in the project EDD file since alternative, more accurate results were provided for the analyte.

For samples analyzed at multiple dilution levels, reported positive concentrations were compared between runs for similarity in concentration. As a conservative approach, unqualified positive concentrations reported above the MRL were identified as the reportable results over undetected results for same target analytes regardless of dilution level.

3.3.1.7 Comparison to Existing ARARs and Proposed Action Levels

COCs exceeding ACLs, PRGs or MCLs or with reporting limits above those value may not be protective. These COCs include the following:

- Acenaphthene ≥PRG in MW-14S, RW-1S
- Benzo(a)anthracene ≥PRG in MW-3S, MW-15SR, RW-12SS, MW-14S, RW-1S, MW-11IR, MW-15IR, MW-14I, MW-16I
- Benzo(a)anthracene RL≥PRG in MW-3S
- Benzo(a)pyrene ≥PRG in MW-3S, MW-11S, MW-15SR, RW-6SR, RW-12SS, MW-14S, RW-1S, MW-3I, MW-15IR, MW-16I
- Benzo(a)pyrene RL≥PRG in MW-3S, MW-11S, RW-6SR, RW-12SS, MW-3I, MW-16I
- Benzo(a)pyrene ≥PRG, MCL in MW-15SR, RW-1S, MW-11IR, MW-15IR, MW-14I
- Benzo(a)pyrene RL≥PRG, MCL in MW-14S
- Benzo(b)fluoranthene ≥PRG in MW-3S, MW-11S, MW-15SR, RW-12SS, MW-14S, RW-1S, MW-11IR, MW-15IR, MW-16I
- Benzo(b)fluoranthene RL≥PRG in MW-3S, MW-11S, MW-14S, MW-16I
- Benzo(k)fluoranthene ≥PRG in MW-15SR, MW-14S, RW-1S, MW-11IR, MW-15IR, MW-14I
- Benzo(k)fluoranthene RL≥PRG in MW-14S
- Chrysene ≥ACL, PRG in MW-14I
- Chrysene ≥PRG in MW-15SR, MW-14S, MW-11IR, MW-15IR
- Chrysene RL≥PRG in RW-1S
- Dibenz(a,h)anthracene ≥ACL, PRG in MW-14I
- Dibenz(a,h)anthracene ≥PRG in MW-3S, MW-15SR, RW-6SR, RW-12SS, RW-1S, MW-3I, MW-15IR, MW-16I
- Dibenz(a,h)anthracene RL≥PRG in MW-3S, MW-15SR, RW-6SR, RW-12SS, MW-3I, MW-15IR, MW-16I
- Dibenzofuran ≥ACL in MW-14I
- Fluoranthene ≥ACL in MW-14I
- Fluorene ≥ACL, PRG in MW-14I
- Fluorene RL≥ACL, PRG in MW-14I
- lndeno(1,2.3-cd)pyrene ≥ACL, PRG in MW-15IR, MW-14I, MW-16I
- lndeno(1,2.3-cd)pyrene ≥PRG in MW-3S, MW-15SR, RW-6SR, MW-14S, RW-1S, MW-3I, MW-11IR, MW-15IR, MW-16I
- lndeno(1,2.3-cd)pyrene RL≥PRG in MW-3S, RW-6SR, MW-14S
- Naphthalene ≥ACL, PRG in MW-15IR, MW-14I
- Naphthalene ≥PRG in RW-6SR, MW-14S, MW-3I, MW-14I, MW-16I
- Naphthalene RL≥PRG in MW-3S in MW-3S
- Pentachlorophenol RL≥PRG in MW-3S, MW-11S
- Pentachlorophenol RL≥MCL in MW-3S

- Pentachlorophenol ≥PRG, MCL in MW-15SR, RW-6SR, RW-12SS, MW-14S, RW-1S, MW-3I, MW-11IR, MW-15IR, MW-14I, MW-16I
- Pyrene ≥PRG in MW-14I

3.4 2008 Sampling Data

The 2008 groundwater monitoring events occurred in September. Laboratory results ware reviewed to determine if the data was usable. Results indicate that the data is acceptable as discussed in the data validation reports (Appendix D).

Groundwater Sample ID	Sample Date	Sample Time	Laboratory ID	PAHs	Total Zinc	PCP	Dibenzofurans
SDG NO85							
RW-6SR	09/09/2008	0935	NO85A	X	X	X	X
MW-3S		1150	NO85B	X	X	X	X
MW-3D		1032	NO85C	X	X	X	X
MW-3I		1120	NO85D	X	X	X	X
MW-14S		1317	NO85E	X	X	X	X
MW-14I		1350	NO85F	X	X	X	X
RW-1S		1447	NO85G	X	X	X	X
MW-16I		1515	NO85H	X	X	X	X
MW-16I (field dup)		1532	NO85I	X	X	X	X
MW-11S	09/10/2008	1417	NO85J	X	X	X	X
MW-11IR		1350	NO85K	X	X	X	X
MW-15IR		1005	NO85L	X	X	X	X
MW-15SR		1042	NO85M	X	X	X	X
RW-12S	09/11//2008	1225	NO85N	X	X	X	X
MW-15D		1115	NO85O	X	X	X	X
Method Key: PAHs, dibenzofuran (8270C SIM); PCP (8151); total zinc (6010B)							

3.4.1 Data Quality Indicators

3.4.1.1 Precision

Sample-specific analytical precision (MS and MSD recoveries) could not be measured for this event because insufficient sample volume was available to perform MS/MSDs. LCS/LCD were performed for 8270 (PAH) and 8151 (PCP) in order to demonstrate method-specific precision.

The PAH LCS/LCSD recoveries and relative percent differences (RPDs) met the acceptance criteria with the exception of the naphthalene recovery in the LCSD (174%). <u>Since all of the other technical acceptance criteria were met, none of the associated sample results were qualified on this basis.</u>

The PCP LCS/LCSD recoveries (32%) were low indicating low bias in the associated results. Due to possible low bias, the PCP reported in all samples were qualified estimated, “J/UJ”.

3.4.1.2 Accuracy

Due to the high levels of PAHs native to the samples, the surrogate recoveries were diluted-out and not reported. None of the PAH results were qualified on the basis of surrogate recoveries.

The PCP surrogate recoveries for samples PSR01 (26%), PSR14 (40%), LCS (44%) and LCSD (45%) did not meet the control limits indicating low bias in the associated results. Due to low surrogate recoveries, the PCP reported for samples PSR01 and PSR14 were qualified estimated, “J/UJ”.

The PAH LCS/LCSD recoveries and relative percent differences (RPDs) met the acceptance criteria with the exception of the naphthalene recovery in the LCSD (174%). Since all of the other technical acceptance criteria were met, none of the associated sample results were qualified on this basis.

The PCP LCS/LCSD recoveries (32%) were low indicating low bias in the associated results. Due to possible low bias, the PCP reported in all samples were qualified estimated, “J/UJ”.

The frequency of analysis of laboratory blanks was met. The PCP method blank was clean and acceptable. None of the PCP data were qualified on the basis of method blank contamination.

Naphthalene was detected in the method blank at about 9x the RL or at 87.66 ng/ml on column. Because the analysis is set on an ultra-low level, this contamination significantly affects the reported naphthalene in the associated samples. In addition, 1-methyl naphthalene (6.29 ng) and phenanthrene (5.9 ng) were also detected but were not reported because the values were less than the RLs. According to the Case Narrative, the contamination was from cross-contamination from samples (PSR05, PSR06, PSR07, PSR12) with high levels of PAHs during sample extraction and processing and not from carry-over. Sample PSR06 alone required three runs and a final 25000x dilution to get the concentrations of detected compounds within the instrument calibration range. Although only naphthalene, 1-methyl naphthalene and phenanthrene were detected in the method blank, re-creation of the sample extraction and clean-up scenarios from lab bench sheets indicated that, samples PSR05, PSR06 and PSR07 were actually located 6-8 samples away from the method blank and actually closer to the other samples than the blank. If cross-contamination occurred, there’s a bigger probability that the samples were contaminated first before the method blank.

Due to the unpredictable extent of cross-contamination with other samples and the low action levels for the contaminants, the PAHs detected in the samples were qualified using the (1) reviewer's professional judgment and (2) the concentrations the PAHs detected in sample PSR06 as a basis. All PAHs detected in the samples at concentrations <250 ug/L (RLs for PS06) were qualified as non-detects, "U" with RLs elevated at the level of compound detections. Detections >250 ug/L were qualified estimated, "J", due to possible contributions from cross-contamination.

3.4.1.3 Representativeness

All field samples were collected using the same sampling techniques. No field work variances or other anomalies in protocol were notes. Therefore, samples are considered representative of native groundwater conditions.

3.4.1.4 Completeness

All of the reportable data so determined are usable, some with qualification. Since no data were missing or rejected, completeness of the data set was calculated to be 100% and is acceptable.

3.4.1.5 Comparability

All data was generated by EPA SW-846 analytical methods appropriate to the analytes of concern. However, Method 8151 rather than 8270 (SIM) was used to analyze for PCP. The method control criteria and QA/QC procedures set forth in the project-specific QAPP were consistently applied. Therefore, the data can be confidently represented as comparable.

3.4.1.6 Sensitivity

Method 8270D (PAH) - All of the samples were prepared and analyzed at the requested project reporting limits. However, several samples should have been analyzed using full scan Method 8270D instead of the SIM techniques. Due to the high levels of PAHs native to some of the samples, multiple analyses had to be performed and only the final dilution run results were submitted. This elevated the reporting limits (RLs) for some of the undetected PAH target compounds and may not meet the project target analytical concentration goals.

Method 8151 (PCP) - For PCP analysis, there were 3 samples that had elevated reporting limits due to interferences in one or both columns. This reviewer flagged the PCP as non-detects at the estimated RLs. Two samples analyzed for PCP required dilutions. Data users are advised to use the dilution values for these samples (PSR05 and PSR13) for PCP.

3.4.1.7 Comparison to Existing ARARs and Proposed Action Levels

COCs exceeding ACLs, PRGs or MCLs or with reporting limits above those value may not be protective. These COCs include the following:

- Acenaphthene ≥PRG in MW-14S
- Benzo(a)anthracene ≥PRG in RW-12S, MW-11IR, MW-14I, MW-15D
- Benzo(a)anthracene RL≥PRG in MW-14S, RW-1WS, MW-15IR, MW-16I
- Benzo(a)pyrene ≥PRG in RW-12S
- Benzo(a)pyrene ≥PRG, MCL in MW-15SR, MW-14S, MW-11IR, MW-14I, MW-15D
- Benzo(a)pyrene RL≥PRG in MW-3S, MW-11S, RW-6SR, MW-15IR, MW-16I, MW-3D
- Benzo(a)pyrene RL≥PRG, MCL in RW-1S, MW-3I
- Benzo(a)pyrene RL≥PRG, MCL, ACL in MW-15IR
- Benzo(b)fluoranthene RL≥PRG in MW-3S, MW-11S, MW-15SR, RW-6SR, MW-14S, RW-1S, MW-3I, MW-11IR, MW-14I, M MW-16I, , MW-3D
- Benzo(g,h,i)perylene
- Benzo(k)fluoranthene ≥PRG in RW-12SW, MW-14I, MW-16I, MW-15D
- Benzo(k)fluoranthene RL≥PRG in MW-11S, MW-15SR, RW-1S, MW-11IR, , MW-3D
- Benzo(a)anthracene RL≥PRG in MW-16R, MW-15SR
- Chrysene >ACL, PRG in MW-14I
- Chrysene RL≥PRG in MW-15SR, MW-14S, RW-1S, MW-16I
- Dibenz(a,h)anthracene ≥PRG in
- Dibenz(a,h)anthracene RL≥PRG in MW-3S, MW-15SR, RW-6SR, RW-12SW, MW-14S, RW-1S, MW-3I, MW-11IR, MW-14I, , MW-3D, MW-15D
- Dibenzofuran >ACL in MW-14I
- Fluoranthene >ACL, PRG in MW-14I
- Fluorene >ACL, PRG in MW-14I
- lndeno(1 ,2.3-cd)pyrene RL>ACL in MW-14I
- lndeno(1 ,2.3-cd)pyrene ≥ACL, PRG in MS-14S, MW-15IR
- lndeno(1,2.3-cd)pyrene RL ≥ACL in MW-15SR, MW-14S
- lndeno(1 ,2.3-cd)pyrene RL ≥ACL, PRG, MW-15SR
- lndeno(1,2.3-cd)pyrene ≥PRG in MW-11S,
- lndeno(1,2.3-cd)pyrene RL≥PRG in MW-3S, RW-6SR, RW-12S, RW-1S, MW-3I, MW-11IR, MW-16I, , MW-3D
- Naphthalene ≥ACL, PRG in MW-14I, MW-15IR
- Naphthalene ≥PRG in MW-15SR, MW-14S, MW-11IR, MW-16I, MW-15D
- Naphthalene ≥PRG, MCL in RW-1S
- Pentachlorophenol ≥PRG, MCL in MW-15SR, MW-14S, MW-15IR, MW-14I
- Pyrene ≥PRG in MW-14I

4.0 Data Usability

Data usability assessment is the process of assuring that the quality of data generated meets the intended use. Usability is by established when the data is of known and acceptable uncertainty. Uncertainty is acceptable when the following criteria have been established and understood to be adequate:

- Data Sources and Documentation

    - Upland Groundwater Remedy Sampling and Analysis Plan, Pacific Sound Resources Superfund Site – Terminal 5 (RETEC/AECOM, 1 March 2004)
    - Upland Groundwater Remedy 2003 Annual Monitoring Report, Pacific Sound Resources Superfund Site, Seattle, Washington (RETEC/AECOM, 7 June 2004)
    - Upland Groundwater Remedy 2004 Annual Monitoring Report, Pacific Sound Resources Superfund Site, Seattle, Washington (RETEC/AECOM, 31 May 2005)
    - Upland Groundwater Remedy 2005 Annual Monitoring Report, Pacific Sound Resources Superfund Site, Seattle, Washington (RETEC/AECOM, 12 June 2006)
    - Data Validation Report for the Polynuclear Aromatic Hydrocarbon (PAH) and Pentachlorophenol (PCP) Analysis of Groundwater Samples Collected from the Pacific Sound Resources Terminal 5 (USEPA Region 10 Office of Environmental Assessment, 12 November 2008)

- Analytical Methods

    - EPA SW-846 Methodology as described in the QAPP
    - Seattle District USACE Contract 912DW-04-D-1012 (Task Order 28, Modification 1)

- Data Quality

    - Upland Groundwater Remedy Sampling and Analysis Plan, Pacific Sound Resources Superfund Site – Terminal 5 (RETEC/AECOM, 1 March 2004)
    - Seattle District USACE Contract 912DW-04-D-1012 (Task Order 28, Modification 1)

- Data Review

    - USEPA Contract laboratory Program National Functional Guidelines for Organic/Inorganic Data Review, document numbers EPA540/R-99/008
    - EPA540/R-01/008 of October 1999 (Organic) and July 2002 (Inorganic) as they applied to the reported methodology.
    - Field duplicate RPD control limits were taken from the USEPA Region I Laboratory Validation Functional Guidelines for Evaluating Organic Analysis, February 1988, upheld in Draft 1993.

Based on the uncertainty associated with the criteria above, all data are usable for the intended purpose. However, the data user is cautioned that high analyte concentrations and/or interferences limit the usability of some data as described Table 1. Although the uncertainty of the historic data is known, much of it is not useful for comparison to ARARs. It is recommended that alternate analytical strategies including cleanup step be considered in future monitoring events in order to achieve reporting limits that are at or below the level of revised ARARs.

Attachment 4

Site Inspection Report with Photographs

Attachment 4, Site Inspection Report

Puget Sound Resources Superfund Site, Seattle, WA
(EPA ID: WAD009248287)

1 Site Information

The US Army Corps of Engineers (USACE), Seattle District is the lead agency responsible for conducting the second Puget Sound Resources (PSR) Superfund Site Five-Year Review. The US Environmental Protection Agency (EPA) Region 10 is the lead agency for site remediation.

The PSR Superfund Site, formerly known as the Wyckoff West Wood Treating Facility, is located on the south shore of Elliott Bay in Puget Sound, Seattle, Washington (Figure 1). The site is divided into two operable units: the Upland Unit and the Marine Sediments Unit. The Upland Unit consists of the former wood-treating facility and occupies an area of approximately 25 acres; the Marine Sediments Unit encompasses approximately 58 acres of Elliott Bay and approximately 2,000 feet of shoreline. The majority of the Upland Unit area is an active port terminal that is owned by the Port of Seattle (Port) and leased to Eagle Marine Services. The remaining portion of the Upland Unit area, adjacent to the shoreline, is publicly owned and serves as a public access park.

The site inspection was conducted on 19 November 2008 between 0800 and 1100, by USACE team members Miriam Gilmer (Project Manager), Mandy Michalsen, John Wakeman, Chemine Jackels, Lisa Scott, and Gwendolyn Hannam. EPA Region 10 team members Ravi Sanga (Remedial Project Manager) and Rene Fuentez also participated in the site inspection, along with Warren Hansen (WindWard Environmental, Inc., Contractor to the Port of Seattle) and Gary Young (Eagle Marine Services, Ltd., Port Tenant). The purpose of the site inspection was to record site and vicinity observations, identify deficiencies or other site issues, and to conduct interviews with individuals familiar with the site. The site interviews were conducted between 1100 and 1200 in a conference room on site, by USACE team members Mandy Michalsen and Gwendolyn Hannam.

2 Interviews

2.1 Warren G. Hansen, P.E., Contractor to the Port of Seattle, WindWard Environmental Inc., (206) 812-5434.

Warren Hansen has provided contractor services to the Port of Seattle since 1991. He provided technical support during early property redevelopment, site cleanup, and slurry wall design. Mr. Hansen has overseen the upland asphaltic concrete cap monitoring program since 1998. Every year he and his team conduct a site walk inspection, which includes an evaluation of (a) security fence integrity, (b) asphalt cracks greater than one-quarter inch, (c) asphalt subsidence greater than 3 inches, (d) painted boundary marker wear, (e) ponding water greater than four inches in depth, and (e) integrity of sealant surrounding the train tracks. Results of the site walk inspections are published in Annual Cap Inspection Reports, which are presented in interactive compact disk format and include site maps, copious photographs, and completed cap inspection forms.

Mr. Warren noted that the asphalt cap is currently in good condition, although several painted boundary markers are worn and need replacement. Per Mr. Warren's suggestion, the Port has arranged for replacement of worn pavement markers during the next dry season (tentatively scheduled for summer 2009). T he Port is considering replacement of the cap sealant with a non-coal tar sealant and have applied a test patch to the surface of the cap near monitoring well RW-6SR to evaluate performance (Photo 1). Pending performance of the test patch, the entire cap sealant may be replaced with the non-coal tar sealant.

Mr. Warren noted that storm water runoff from all but the southern portion of the asphalt cap drains to the Longfellow drainage pipe, which discharges directly to Elliott Bay. Storm water runoff from the southern portion of the site drains to a separate pipe, which discharges to the West Waterway. Storm water runoff from the site is not treated prior to discharge.

Mr. Warren's overall impression of the site was positive. He understands that the public access park is well used and enjoyed with no negative feedback. The only site changes he was aware of since the last Five-Year Review were (a) removal of the safety nets prohibiting fishing in the public area in October 2008, and (b) the sinking of the rail transfer dock in early 2007[1]. He noted that to his knowledge, the Port commissioned Anchor Environmental approximately one year ago (2007) to monitor positioning of the sunken dock, but that no action has been taken to remove it.

2.2 Gary Young, Maintenance/Repair Superintendent, Eagle Marine Services Ltd., (206) 793-0405.

Gary Young has been with Eagle Marine Services since 1993, and has maintained the building and yard repairs on the PSR site since 2008. At the time of the interview, Mr. Young had been the primary site point of contact for asphalt cap maintenance for approximately 7 months. He appreciated the site tour as it provided him with good information and underscored the importance of careful coordination for all cap maintenance activities, such as not painting over cap markings. He noted that all asphalt repairs, including pothole repairs, are coordinated with the Port and with Mr. Warren. He also noted that site use does not change, but positioning of site activities/site configuration does change from time to time, which requires coordination with the Port.

Mr. Young's overall impression of the site was positive. He noted that the site is well maintained and that asphalt crack sealants are in good condition.

3 On-site Documents and Records Verified

No on-site documents or records were verified during the site visit.

4 Operation and Maintenance Costs

Operations and Maintenance costs were provided via e-mail and are included in the main report.

[1] This date was obtained from the memorandum from Integral Consulting, Inc. dated March 8, 2007, subject: *USACE Contract W912DW-06-D-1003 DO 0005 – PSR Technical Support Sunken Dock*.

5 Access and Institutional Controls

The Upland Unit area occupied by the Port of Seattle is securely enclosed by a combination of gated entrances that are monitored by security personnel and a 10-foot barbed wire topped chain-link fence (Photo 2). Shoreline access in the public park area is also restricted by chain-link fences with placards informing the public of intended site use and prohibited activities including fishing and beach access (Photos 3, 4, and 5). The bottom portion of the chain-link fence fishing barrier, which extended from the base of the public access area dock, was removed in October 2008 to prevent the public from potentially using the barrier as a way to access the shoreline (Photo 6).

Lack of complete institutional controls in both the Upland Unit and Marine Sediments Unit was identified as an issue during the first Five-Year Review, and this issue remains unresolved. Institutional controls are necessary to ensure (a) continued protection by early actions, (b) that current land use is maintained, and (c) that the aquifer remains unused. Neither the recommended deed restriction in the Upland Unit nor the "no anchor zone" control in the Marine Sediments Unit have been implemented at the time of this second Five-Year Review.

6 General Site Conditions

The majority of the Upland Unit is an active asphalt-covered port terminal with train tracks owned by the Port of Seattle and leased by Eagle Marine Services. The asphalt cap consists of 8-inch and 4-inch sections, as indicated on Figure 1. Traffic flow within the Port terminal is restricted by concrete ecology blocks, which prevent traffic access to the site along the eastern site boundary (Photo 7). There is also a single slab-on-grade building constructed on the 8-inch cap in the central northwest portion of the site (Photos 7 and 8).

Public access to the Port terminal is restricted by a chain-link barbed wire fence along the northern and western portions of the site, which border the public park access area. Painted markers on the asphalt demarcate the 8-inch and 4-inch areas of the asphalt cap (Photo 9) and the location of the slurry wall, but the markers are worn (Photo 10) and will be replaced during the next dry season (tentatively scheduled for summer 2009). Train tracks are located throughout the active terminal. Associated with the train tracks are uncapped "switch pits" (Photo 11). Gary Young had commented that the exposed soil is part of the clean soil that was put in before the installment of the eight inch cement cap. These uncapped areas constitute a small portion of the total capped area and the infiltration expected through these areas was addressed during the cap design.

Cracks in the asphalt cap that resulted from the Nisqually earthquake in 2001 have been filled and resealed (Photo 12). Photo 11 was taken near the location of the 4-inch to 8-inch cap transition area indicated on Figure 1, looking toward the northern-most portion of the site. Standing water was observed near this vicinity (Photo 13). According to Warren Hansen and Gary Young, standing water more than 4 inches deep on capped areas requires removal to prevent future ponding and could trigger cap repair. Abandoned piezometers were also observed near the ponding water and along the northern-most train track in the 4-inch capped area (Photo 14).

The public access area is clean and well maintained, with natural landscaping, a public access road and sidewalks (Photo 15), and observation deck (Photo 16). There is also a small public restroom building constructed in the park area (Photo 17). Monitoring wells located in the public access area allow for groundwater quality monitoring beyond the slurry wall containment area. All monitoring wells were intact; however, none of the wells were secured, and wells RW-1I and RW-1D were missing well caps (Photos 18 and 19, respectively).

The "rail transfer span" sank in early 2007 (Photo 20). A review of memorandums related to the sunken dock is provided in the main report. Briefly, there is currently no evidence that the sunken dock is impacting the sediment cap at this time.

A rail car derailment occurred at the Burlington Northern-Santa Fe (BNSF) Railway Storage yard at Terminal 5 during the weekend of February 3, 2007 (CH2M Hill 2007). This area of the BNSF yard is located within the security fenced area south of the main public access pier and west of the public restroom building. The derailment caused damage to the Port's security fence, the rail stopper, asphalt and curb north of the BNSF yard in the public access area, the 4-foot chain-link fence along the beach, and a 12-foot by 15-foot plot of vegetative habitat north of the 4-foot chain-link fence. To date, all associated repairs have been completed (Photo 21). There is no existing damage to the remedy as a result of the rail car derailment.

7 Vertical Barrier Walls

The containment slurry wall indicated in Figure 1 provides a vertical barrier to shallow groundwater transport to Elliott Bay and also reduces tidal influence on the upland shallow groundwater table. Faded markers that designate the slurry wall location were observed during the site visit (Photo 10). We understand that these markers are tentatively scheduled to be replaced during summer 2009.

8 Groundwater/Surface Water Remedies

The containment slurry wall and the asphalt cap comprise the upland groundwater remedy. There is currently no surface water remedy.

9 Other Remedies

The Upland Unit remedy consists of the containment slurry wall and asphalt cap, and the Marine Sediments Unit remedy consists of the sediment cap. There are no other remedies.

10 Overall Observations

Overall, the main deficiency discovered was the worn painted markings and monitoring well caps that need to be secured. The asphalt cap and public access areas appear to be well maintained and the overall site conditions are good.

SITE INSPECTION FIGURES

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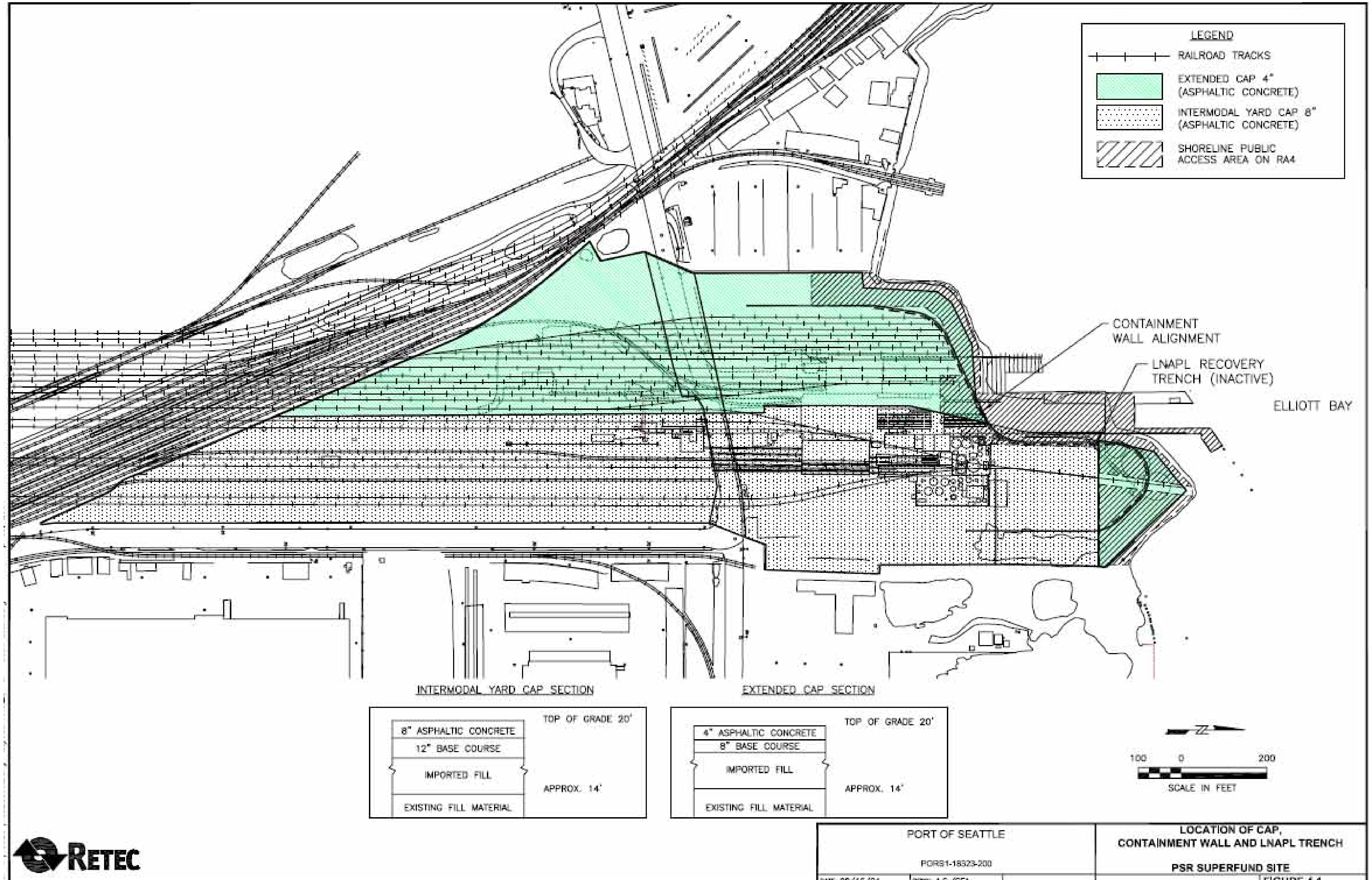

Figure 1. Location of the cap, slurry wall and LNAPL collection trench. Note that site features such as old tank farm and buildings indicated on this drawing no longer exist on site.

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SITE INSPECTION PHOTOS

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Photo 1. The entire cap sealant may be replaced with the non-coal tar sealant, depending on the performance of this non-coal tar test patch.

Photo 2. The upland area of the site is secured by a 10-foot barbed wire topped chain-link fence.

Photo 3. Photo shows one of many warning placards within the public area, indicating the use of the area.

Photo 4. Photo shows the public park area placard informing the public of intended site use.

Photo 5. Photo shows placards that clearly indicate the boundaries of the public access area.

Photo 6. Photo shows the fishing barrier that extended from the base of the public access area dock. This was removed in October 2008.

Photo 7. Photo shows concrete ecology blocks that prevent traffic access along the eastern site boundary.

Photo 8. Photo shows the slab-on-grade building constructed on the 8-inch capped area in the central northeast portion of the site.

Photo 9. Photo shows worn marking that distinguishes the location of the 4-inch and 8-inch thick asphalt cap areas.

Photo 10. The painted location indicators for the slurry wall are worn.

Photo 11. Photo shows switching pits where soil is exposed.

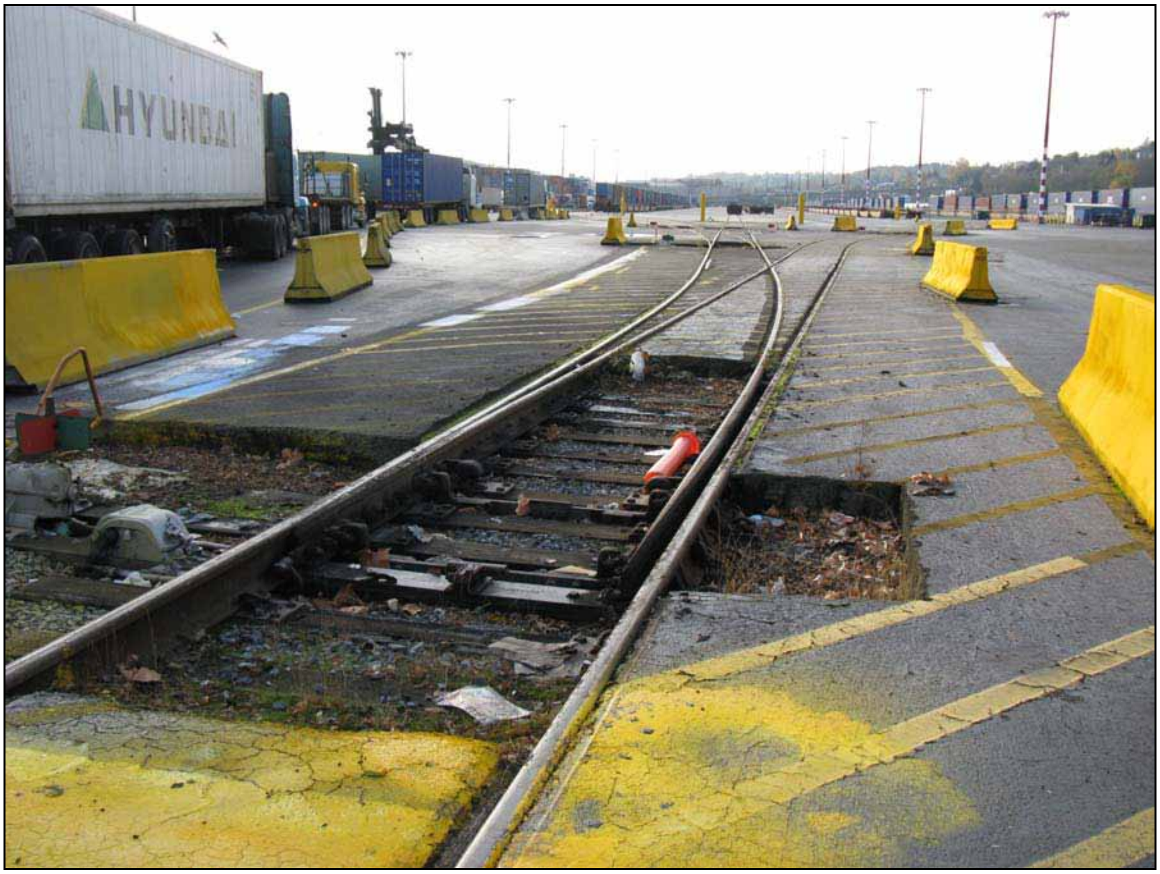

Photo 12. Photo shows asphalt that has been filled and resealed.

Photo 13. Photo shows standing water at the edge of asphalt borders, located at the northern-most railroad track areas.

Photo 14. Photo shows abandoned piezometers along the northern-most train track.

Photo 15. Photo shows the public access area looking westward.

Photo 16. Photo shows the observation deck constructed in the public access area, as viewed from below on the northern-most portion of the 4-inch capped area (see Figure 1).

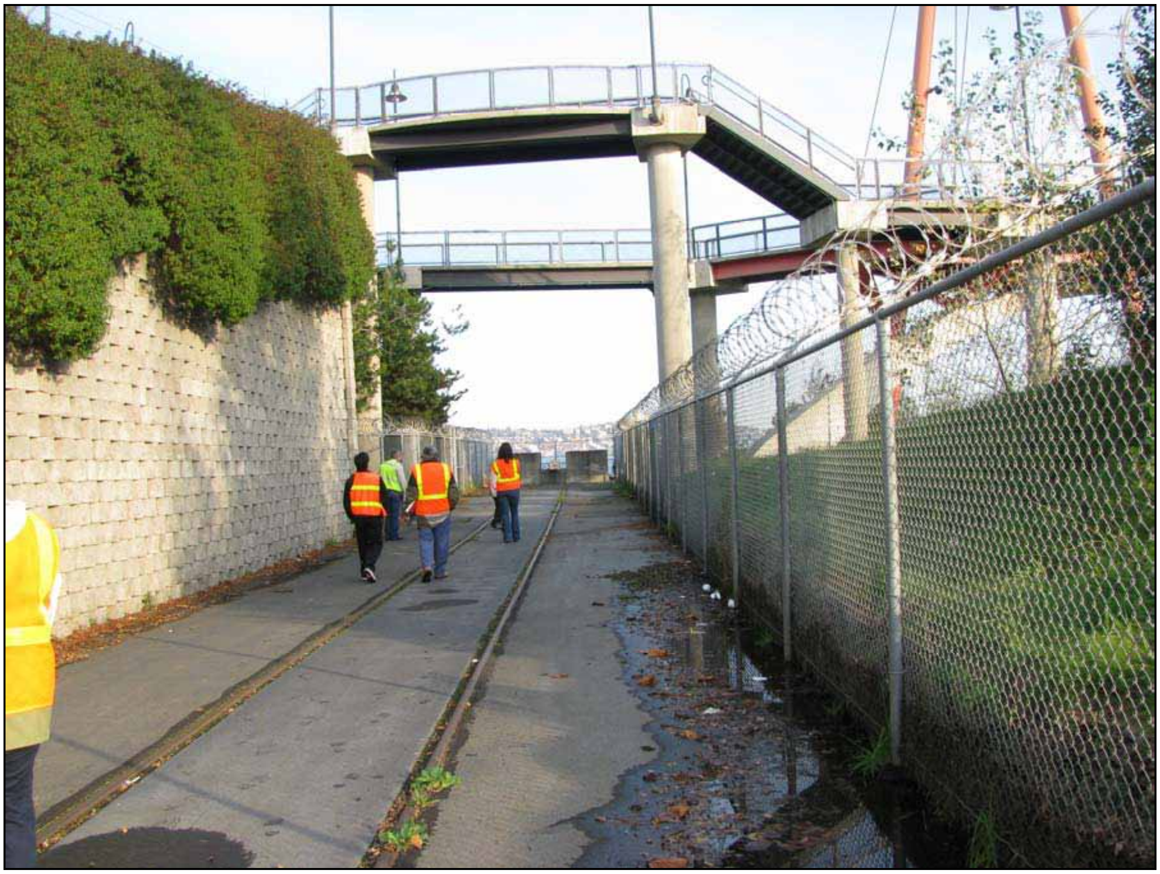

Photo 17. Photo shows the public restroom building in the park area looking in a southwesterly direction.

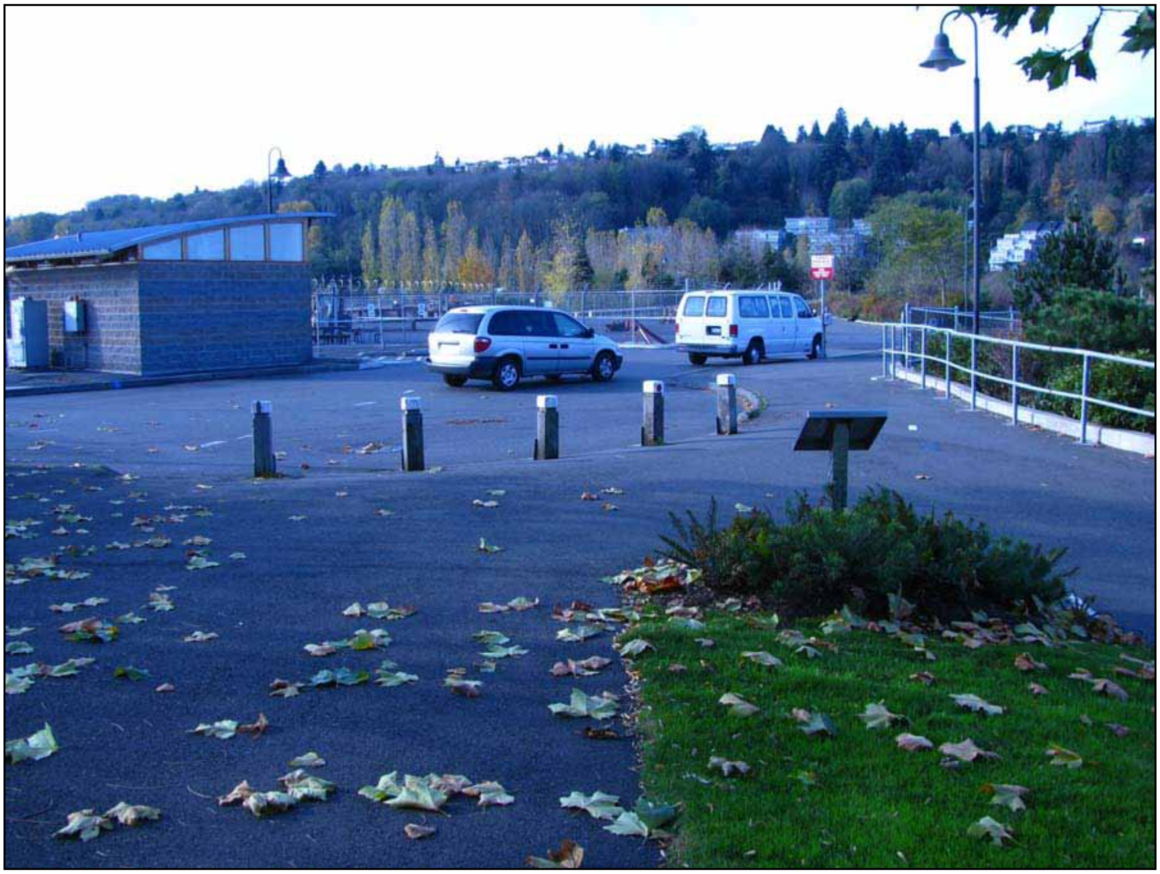

Photo 18. Photo shows unsecured well RW 1I. Note that the sheen on the well casing water is likely ferrihydrite due to corrosion of the well casing, not product.

Photo 19. Photo shows unsecured well RW 1D. Note that the sheen on the well casing water is likely ferrihydrite due to corrosion of the well casing, not product.

Photo 20. Photo shows the sunken dock in the northwest area of the site, looking in a northwesterly direction.

Photo 21. Photo shows rail car derailment damage repair, looking in a northeasterly direction.

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Attachment 5

Review of Potentially Applicable or Relevant and Appropriate Requirements

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Attachment 5, EPA Review of Potentially Applicable or Relevant and Appropriate Requirements

1. Introduction

Review of the applicable or relevant and appropriate requirements (ARARs) for Pacific Sound Resources (PSR) listed in the ROD revealed a number of inconsistencies with current interpretation of CERCLA. The ROD made errors arising from its misconstruction and misapplication of the Alternate Concentration Levels (ACLs) in Section 121(d)(2)(B)(ii) of CERCLA. CERCLA is not an ARAR, as it is procedural in nature. Instead, the RI/FS and ROD listed should have listed Maximum Contaminant Levels (MCLs) as defined in the Safe Drinking Water Act as relevant and appropriate requirements for groundwater at the site to the extent that the groundwater is empirically determined to be potable in accordance with Washington Administrative Code (WAC) 173-340-720(2). The ROD should also have listed the more stringent of federal Ambient Water Quality Criteria (AWQC) of the Clean Water Act and state Water Quality Standards as applicable requirements for surface water. The ROD correctly listed Washington Model Toxics Control Act (MTCA) regulations (WAC 173-340-720 et seq.) for groundwater, and Washington Sediment Management Standards (SMS) for sediment as applicable requirements.

2. Surface Water Protection Chemical-Specific ARARs

The ROD concluded that "based on the groundwater classification at PSR (Class IIb and Class III, i.e., non-potable), the impracticability of restoration, and the impracticability of the site meeting the statutory requirements, use of ACLs at PSR is appropriate." There are no Class III groundwaters in Washington State at this time.

The ROD's reliance on aquifer classifications arose from a single sentence in the NCP preamble, and subsequent EPA guidance citing it. That sentence conflicts with Section 121(d)(2)(B)(i) of CERCLA, which does not allow such designations or classifications to affect the requirement in the last sentence of 121(d)(2)(A)(ii) to meet MCLs in groundwater where they are relevant and appropriate requirements under the circumstances of the release (i.e., in cases where groundwater is potable). Any impracticability of restoration or of statutory requirements, presumably those in 121(d)(2)(A) and (B), should have been documented in a technical impracticability (TI) waiver pursuant to 121(d)(4). The NCP preamble sentence and subsequent EPA guidance derived from the same preamble sentence misled the ROD to a conclusion that impracticability could be found without a formally-issued statutory waiver.

Although the ROD relied on aquifer classifications to determine non-potability at the site, it decided to calculate and apply ACLs. The Administrative Record suggests that EPA believed at least a portion of the groundwater beneath the site (at depth and furthest from the shoreline) was likely to be potable. The ROD also appears to have employed ACLs to ensure compliance with surface water standards. WAC 173-340-720(1)(c) states, “Groundwater cleanup levels shall be established at concentrations that do not directly or indirectly cause violations of surface water, sediments, soil, or air cleanup standards established under this chapter or other applicable state and federal laws”, as the shoreline wells are “alternate points of compliance.” The ROD states that “there will be no statistically significant increase in contaminants in Elliott Bay, after groundwater contaminant concentrations are attenuated between the shoreline wells and the marine water/sediment interface (i.e., the mudline).” “No statistically significant increase” is terminology from Section 121(d)(2)(B)(ii)(II) of CERCLA, a requirement of properly-applied ACLs. ACLs are limited to replacing “otherwise applicable” requirements, such as anti-degradation laws or regulations. Drinking water standards are not only *applicable* requirements for groundwater used for drinking, but they are also relevant and appropriate requirements for potable ground or surface water that could be used for drinking water. Nevertheless, the ROD used this criterion for ACLs as a means to calculate and predict compliance with WAC 173-340-720(1)(c) . This WAC and federal AWQC are applicable requirements.

Despite the improper use in the ROD, the ACL calculations are useful to help predict the impact from the site on surface water quality and whether surface water ARARs will be met. With respect to groundwater, dense non-aqueous phase liquid (DNAPL) at PSR represents a long-term continuing source of contamination to groundwater and surface water. As stated in the ROD, “the DNAPL is widespread and the distribution is complex as a result of the interbedding of coarse and fine-grained soil layers in the aquifer … Currently available remedial technologies do not appear (practicably) capable of restoring the aquifer to drinking water standards” within a reasonable restoration timeframe. However, as noted in the main report, ACLs have been exceeded at several compliance wells, and there are issues regarding the modeling associated with the creation of ACLs.

As stated above, a CERCLA TI waiver was not pursued at the time of the ROD. TI waivers require a rigorous demonstration that (a) they are employed only to the extent practicably necessary, and (b) the site should be protective of human health and the environment. This process could lead to future selection by EPA of an ACL-like cleanup standard that requires groundwater to be as close to drinking water standards as can be practicably achieved, as well as a requiring surface water ARARs to be met as closely as can be practicably achieved. It would require that the extent to which contaminated groundwater may be discharging to surface water be documented and controlled, if impracticable to eliminate.

With respect to surface water quality, the ROD stated, “Uplands RI/FS calculations of constituent concentrations from shoreline monitoring well data project that there will be no statistically significant increase in contaminants in Elliott Bay, after groundwater contaminant concentrations are attenuated between the shoreline wells and the marine water/sediment interface (i.e., the mudline). Under the MTCA, the shoreline wells would be considered an alternate point of compliance, as they will be used to predict the contaminant concentration at the mudline.” However, in the FS, the basis for the statistically-significant statement is unclear. The FS modeling used pore water concentrations at the mudline compared to whichever was most stringent: a) the AWQC,

b) the MTCA surface water Method B values, or c) pore water concentrations that could compromise sediment-based Washington Sediment Quality Standards based upon equilibrium partitioning. The FS approach confirms that the TI waiver would be limited to groundwater and would not include surface water. Thus, the waiver would need to confirm that groundwater does not daylight to surface water currently or in a reliably projected future.

MTCA B, WAC 173-340-730(3), requirements for surface water cleanup include the following, which are applicable requirements for PSR:

- Water quality criteria published in the water quality standards for surface waters of the state of Washington, chapter WAC 173-201A.

- Water quality criteria based on the protection of aquatic organisms (acute and chronic criteria) and human health published under Section 304 of the Clean Water Act unless it can be demonstrated that such criteria are not relevant and appropriate for a specific surface water body or hazardous substance.

- The national toxics rule (40 CFR Part 131).

Table A5-1 displays potentially applicable chemical-specific requirements for PSR discharges to surface water. The lowest values are underlined and italicized. For comparison, the table also shows the calculated values protective of recontamination of sediment above the Sediment Quality Standards. This is not a potential ARAR. To determine compliance, direct measurements to the extent practicable in sediment near the surface at the point of predicted groundwater discharge to surface water appear to be appropriate.

3. Groundwater Chemical-Specific ARARs

Whether PSR groundwater must meet or waive MCLs depends upon a nonpotability determination. WAC 173-340-720(2)(a) states that an aquifer is potable if it “could be used as a current or future water supply” (referencing aquifer yield), and WAC 173-340-720(2)(b) states that it must have “sufficiently low salinity.” Neither of these conditions for potability are likely met in the contaminated shallow groundwater near the shoreline. However, WAC 173-340-720(2)(c) requires a further demonstration that contaminants which exceed groundwater quality standards published in WAC 173-200 are unlikely to be transported from a contaminated aquifer to groundwater that is a current or potential future source of drinking water, as defined in WAC 173-340-720(2)(a) or WAC 173-340-720(2)(b). There are two important data gaps that prevent an evaluation of this last criterion: a) whether vertical contaminant transport occurs from the contaminated aquifers to the deeper groundwater beneath the site through the Lawton formation; and b), whether the deeper water body is a current source or potential future source of drinking water. Neither of these conditions are currently verifiable, making the non-potability determination impossible. Therefore, MCLs and MTCA Method C values are tentatively identified as relevant and appropriate requirements for groundwater until such time as potability can be determined. See Table A5-2.

The rationale for using the MTCA to establish medium-specific relevant and appropriate chemical values in Table A5-2 is set forth in WAC 173-340-720(3). PSR does not meet criteria for selection of MTCA Method A (WAC 173-340-705(1)); it is not a "routine cleanup" (WAC 173-340-200), nor does the Site have few hazardous substances. Either Methods B or C could set chemical-specific relevant and appropriate cleanup criteria for site groundwater. Given the setting and the difficult nature of the site subsurface and groundwater, under WAC 173-340-706(1)(a)(iii), MTCA Method C may be used when "MTCA A or B cleanup levels are below technically possible concentrations, but in no case greater than levels specified in subsection (2) of this section." The referenced subsection would establish maximum groundwater risks and hazards, assure protection of aquatic life and wildlife, and assure no trophic contamination would impact human health. MTCA C cleanup standards for risk of consumption would include 1E-05 ILCR for carcinogens and a hazard index of 1[1], which is the point at which non-carcinogens may cause illness in humans. Additionally, WAC 173-340-720(5)(ii) requires protection of surface water for beneficial uses.

4. Sediment Management Standards (WAC 173-204-760)

The Sediment Quality Standards and MCLs, which are relevant and appropriate chemical-specific sediment standards, depicted below in Table A5-2, have not changed since the ROD.

[1] Hazard index means the sum of two or more hazard quotients for multiple hazardous substances and/or multiple pathways. Hazard quotient means the ratio of the dose of a single hazardous substance over a specified time period to a reference dose for that hazardous substance derived for a similar exposure period. For individual noncarcinogenic substances, Method C cleanup levels are set at concentrations which are anticipated to result in no acute or chronic toxic effects on human health (i.e. hazard quotient of 1 or less).

Table A5-1. Potentially Applicable Surface Water Values for Human Health and Aquatic Life

	Surface Water - Human Health Applicable				Surface Water - Aquatic Life Applicable						
Contaminant of Concern	**Marine – Clean Water Act §304** [a]	**Model Toxics Control Act Method B Surface Water (WAC 173-340)**	**Marine – National Toxics Rule - 40 CFR 131.36** [b]	**Lowest Surface Water Concentration - Human Health**	**Marine Acute -. WAC 173-201A**	**Marine Acute - Clean Water Act §304**	**Marine Acute - National Toxics Rule, 40 CFR 131**	**Marine Chronic - WAC 173-201A**	**Marine Chronic - Clean Water Act §304**	**Marine Chronic - National Toxics Rule, 40 CFR 131**	**Lowest Surface Water Concentration – Marine Aquatic Life)**
	(µg/L)	*(µg/L)*	*(µg/L)*	*(µg/L)*	*(µg/L)*	*(µg/L)*	*(µg/L)*	*(µg/L)*	*(µg/L)*	*(µg/L)*	*(µg/L)*
Acenapthene	9.90E+02	*6.4E+02*[d]	NV	*6.40E+02*	NV	NV	NV	NV	NV	NV	NV
Acenaphthylene	NV	NV	NV	NV	NV	NV	NV	NV	NV	NV	NV
Anthracene	4.00E+04	*2.6E+04*[d]	1.10E+05	*2.64E+04*	NV	NV	NV	NV	NV	NV	NV
Benzo(a)anthracene	*1.80E-02*	[e]	3.10E-02	*1.80E-02*	NV	NV	NV	NV	NV	NV	NV
Benzo(a)pyrene	*1.80E-02*	2.96E-02[e]	3.10E-02	*1.80E-02*	NV	NV	NV	NV	NV	NV	NV
Benzo(b)fluoranthene	*1.80E-02*	[e]	3.10E-02	*1.80E-02*	NV	NV	NV	NV	NV	NV	NV
Benzo(k)fluoranthene	*1.80E-02*	[e]	3.10E-02	*1.80E-02*	NV	NV	NV	NV	NV	NV	NV
Benzo(g,h,i)perylene	NV		NV	*NV*	NV	NV	NV	NV	NV	NV	NV
Chrysene	*1.80E-02*	[e]	3.10E-02	*1.80E-02*	NV	NV	NV	NV	NV	NV	NV
Dibenz(a,h)anthracene	*1.80E-02*	[e]	3.10E-02	*1.80E-02*	NV	NV	NV	NV	NV	NV	NV
Fluoranthene	1.40E+02	9.00E+01	3.70E+02	9.00E+01	NV	NV	NV	NV	NV	NV	NV
Fluorene	5.30E+03	*3.46E+03*	1.40E+04	3.46E+03	NV	NV	NV	NV	NV	NV	NV
Indeno(1,2,3-cd)pyrene	*1.80E-02*	*[e]*	3.10E-02	*1.80E-02*	NV	NV	NV	NV	NV	NV	NV
Naphthalene	NV	4.90E+03 [d]	NV	*9.58E+00*	NV	NV	NV	NV	NV	NV	NV
Pentachlorophenol	*3.00E+00*	4.90E+00	8.20E+00	*3.00E+00*	1.30E+01	1.30E+01	1.30E+01	7.90E+00	7.90E+00	7.90E+00	7.90E+00
Pyrene	4.00E+03	*2.59E+03*	1.10E+04	*2.59E+03*	NV	NV	NV	NV	NV	NV	NV
Zinc	2.60E+04	*1.65E+04*	NV	1.65E+04	9.00E+01	9.00E+01	9.00E+01	8.10E+01	8.10E+01	8.10E+01	*8.10E+01*

Notes:
NV = No Values Found
Italicized values are the lowest relevant and appropriate criteria/standards for the PSR Site's protection of surface water.
[a] Washington Administrative Code (WAC) 173-201A-240 (3) and (4): USEPA Quality Criteria for Water, 1986, as revised, shall be used in the use and interpretation of the values listed in subsection (3) of this section
[b] WAC 173-201A-240 (5): "Concentrations of toxic, and other substances with toxic propensities not listed in subsection (3) of this section shall be determined in consideration of USEPA Quality Criteria for Water, 1986, and as revised, and other relevant information as appropriate. Human health-based water quality criteria used by the state are contained in 40 CFR 131.36 (known as the National Toxics Rule)."
[d] These values have been added to the MTCA cleanup levels database since the FS.
[e] All values (carcinogenic PAHs) with this superscript have been regulated by Washington State since October, 2007 as one compound, summed as benzo[a]pyrene Toxicity Equivalents (TEQ), and at a 1E-06 lifetime incremental cancer risk (WAC 173-340-708(e)). This comparison would be made as a second tier, following the use of the Clean Water Act value (shown in the cell), and would reference the Benzo[a]pyrene protection value of 2.96E-02 ug/L. https://fortress.wa.gov/ecy/clarc/FocusSheets/tef.pdf

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Table A5-2. Screening for Relevant and Appropriate Requirements for Groundwater

Contaminant of Concern	Ground Water - Federal Primary Maximum Contaminant Level (MCL)	Groundwater MTCA Method C, Carcinogen, Standard Formula Value (µg/L)	Groundwater MTCA Method C, Non-Carcinogen, Standard Formula Value (µg/L)	Lowest Value (µg/L)
	(µg/L)	(µg/L)	(µg/L)	(µg/L)
Acenaphthene			2.10E+03	**2.10E+03**
Anthracene			1.1E+04	**1.1E+04**
Benzo(a)pyrene Equivalents	2.00E-01	1.20E-01 [a]		**1.20E-01**
Fluoranthene			1.4E+02	**1.4E+02**
Fluorene			1.4E+02	**1.4E+02**
Naphthalenes	--		3.50E+02 [b]	**3.5E+02**
Pentachlorophenol	1.00E+00	7.3E+00	1.10E+03	**1.00E+00**
Pyrene			1.1E+03	**1.1E+03**
Zinc			1.1E+04	**1.1E+04**

Notes

[a] Sum of benzo[a]pyrene toxicity equivalents, derived by multiplying the concentrations by the Toxicity Equivalent Factors (TEFs) show below. (WAC 173-340-708(e) and Table 708-2 (reproduced below from WAC 173-340-900).

Carcinogenic PAH	TEF (unitless)
benzo[a]pyrene	1
benzo[a]anthracene	0.1
benzo [b]fluoranthene	0.1
benzo[k]fluoranthene	0.1
chrysene	0.01
dibenz[a, h]anthracene	0.1
indeno[1,2,3-cd]pyrene	0.1

[b] Total of these compounds: naphthalene, 1-methylnaphthalene and 2-methylnaphthalene

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Attachment 6

Groundwater Monitoring Data

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Attachment 6, Groundwater Monitoring Data

1. PAHs and Dibenzofuran

As shown in the following multipage table, groundwater samples from monitoring wells MW-11S, MW-3I, MW-3S, RW-6SR and MW-3D all had detected PAHs and dibenzofuran, but concentrations of total naphthalenes in these wells were less than the Washington Model Toxics Control Act (MTCA) Method C groundwater value[1]. Concentrations of benzo[a]pyrene were also below the Maximum Contaminant Levels (MCL) in all these wells. Using the method of substituting one-half the detection limit for non-detected values, the benzo[a]pyrene Toxicity Equivalents TEQ for carcinogenic PAHs for these monitoring wells, as well as for MW-3I and MW-11S, were below MTCA Method C values. Concentrations of other PAHs and dibenzofuran were below MTCA Method C values in all these wells.

Groundwater samples from monitoring wells MW-11IR, MW-15SR, MW-16I, RW-1S, RW-12S and MW-15D all had detections of PAHs and dibenzofuran. Concentrations of total naphthalenes in these wells were less than the MTCA Method C value. Monitoring well RW-1S exceeded the fluorene MTCA Method C value. RW-12S had a benzo[a]pyrene detection below the MCL. Groundwater from monitoring well MW-15D exceeded the benzo[a]pyrene MCL. Benzo[a]pyrene was reported as non-detected at concentrations equal to or exceeding the MCL of 0.2 µg/L in the other listed wells. Benzo[a]pyrene TEQ concentrations exceeded the MTCA Method C value for all the listed wells. Groundwater from monitoring well RW-1S exceeded the dibenzofuran MTCA Method C value.

Groundwater samples from monitoring wells MW-14I, MW-15IR and MW-14S all had detections of PAHs and dibenzofuran. Concentrations of total naphthalenes in these wells were nine times the MTCA Method C value. MW-14I total naphthalenes exceeded MTCA C values by a factor of 47. All of the above-listed wells had concentrations of 2-methylnaphthalene and fluorene that exceeded their MTCA Method C values. MW-14I acenaphthene and pyrene concentrations exceeded MTCA Method C values. MW-14I showed a detected benzo[a]pyrene concentration of 360 µg/L, greatly exceeding the MCL. A data issue was identified for MW-14S and MW-15IR in this round: benzo[a]pyrene was reported as non-detected 40 and 80 µg/L in monitoring wells, respectively, much higher than the MCL of 0.2 µg/L. Summed benzo[a]pyrene TEQ concentrations for cPAHs and dibenzofuran exceeded the MTCA Method C value for all these wells. MW-14I groundwater exceeded both dibenzofuran and fluorene Alternate Concentration Levels (ACL).

[1] The MTCA Method C Cleanup Level for naphthalenes includes the sum of 1-methylnaphthalene, 2-methylnapthalene and naphthalene; however 1-methylnaphthalene is not a contaminant of concern at PSR. Total naphthalenes reported for PSR include only 2-methylnaphthalene and naphthalene.

2. PCP

Groundwater samples from monitoring wells MW-6SR, MW-3S, MW-3I, MW-3D, MW-16I, MW-11S, MW-11IR, RW-12S and MW-15D had no detected PCP, although detection limits exceeded the PCP MCL of 1 μg/L (Attachment 5). MW-15SR had detected PCP at 220 μg/L and groundwater from monitoring well MW-14S had PCP at 26 μg/L (estimated, because it was above the instrument calibration range). Also, monitoring wells MW-15IR, MW-14S, MW-15SR and RW-1S exceeded the PCP ACL value of 2.3 μg/L.

3. Zinc

With two exceptions, groundwater samples from monitoring wells were non-detected for zinc, and those wells (MW-3I and RW-1S), were below applicable or relevant and appropriate requirements (ARAR).

Table 1. **Analytical Results for Groundwater Samples. MW-11S**

Chemical (µg/L)	ACLs (µg/L)	Location ID / Sample Date / Sample ID / MCL or MTCA Method C[d] (µg/L)	MW-11S	MW-11S	MW-11S	MW-11S	MW-11S	MW-11S	MW-11S	MW-11S	MW-11S	MW-11S	MW-11S	MW-11S	MW-11S
		Sample Date	5/24/2003	9/9/2003	11/24/2003	2/24/2004	5/19/2004	8/16/2004	11/23/2004	2/24/2005	5/27/2005	8/26/2005	12/8/2005	2/28/2006	9/10/2008
		Sample ID	MW-11S-0503	MW-11S-0903	MW-11S-1103	MW-11S-0204	MW-11S-0504	MW-11S-0804	MW-11S-1104	MW-11S-0205	MW-11S-0505	MW-11S-0805	MW-11S-1205	MW-11S-0206	0908PSR10
2-Methylnaphthalene	-	70	<0.02	<0.012	<0.019	<0.02	<0.02	<0.02	0.0049 J	<0.0027	0.0044 J	0.0054 J	0.088	0.0038 J	0.30
Acenaphthene	>S	2,100	<0.02	<0.02	<0.019	<0.02	<0.02	<0.02	0.0041 J	<0.02	<0.02	0.002 J	0.068	0.0034 J	0.32
Acenaphthylene	3,330	-	<0.02	<0.02	<0.019	<0.02	0.0027 J	0.0045 J	0.004 J	0.0031 J	0.0028 J	0.0031 J	0.006 J	<0.009	<0.1
Anthracene	>S	11,000	0.011 J	0.033	0.011 J	0.014 J	0.06	0.056	0.06	0.062	0.049	0.038	0.026	0.047	<0.1
Benzo(a)anthracene[a]	>S	-	0.0021 J	<0.02	0.0041 J	0.0022 J	<0.02	<0.0081	0.0095 J	<0.02	0.0034 J	<0.02	0.0066 J	0.0092 J	<0.1
Benzo(a)pyrene[a]	>S	0.2	<0.02	<0.02	0.006 J	0.0021 J	<0.02	<0.0081	<0.02	<0.02	<0.02	<0.02	0.0061 J	0.013 J	<0.1
Benzo(b)fluoranthene[a]	>S	-	0.0028 J	<0.02	0.0084 J	0.0041 J	<0.02	<0.014	0.013 J	<0.02	0.0034 J	<0.02	0.0083 J	0.018 J	<0.1
Benzo(g,h,i)perylene[a]	(0.09)/(>S)	-	<0.02	<0.02	0.0064 J	<0.02	<0.02	<0.0099	0.0075 J	<0.02	<0.02	<0.02	0.0061 J	<0.015	<0.1
Benzo(k)fluoranthene[a]	14	-	<0.0024	<0.02	0.0055 J	0.0031 J	<0.02	<0.0099	0.0078 J	<0.02	0.0017 J	<0.02	0.0058 J	0.011 J	<0.1
Chrysene[a]	>S	-	0.003 J	0.0016 J	0.0059 J	0.0033 J	<0.02	<0.01	0.0072 J	<0.0013	<0.0042	<0.02	<0.008	0.012 J	<0.1
Dibenz(a,h)anthracene[a]	>S	-	<0.02	<0.02	<0.019	<0.02	<0.02	<0.02	0.0038 J	<0.02	<0.02	<0.02	<0.02	<0.0038	<0.1
Dibenzofuran	880	70	<0.02	<0.02	<0.019	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	0.04	<0.02	0.15
Fluoranthene	>S	140	0.0052 J	<0.02	0.0081 J	<0.005	<0.02	<0.012	0.014 J	0.004 J	0.0097 J	<0.02	0.024	0.02 J	<0.1
Fluorene	930	140	<0.02	<0.02	<0.019	<0.02	<0.02	<0.02	0.0043 J	<0.02	<0.02	<0.02	0.027	0.004 J	0.16
Indeno(1,2,3-cd)pyrene[a]	0.47	-	<0.0024	<0.02 J	<0.0086	0.0021 J	<0.02	<0.0099	0.0097 J	<0.02	<0.02	<0.02	0.0058 J	0.016 J	<0.1
Naphthalene	>S	-	<0.017	<0.032	<0.009	<0.0068	<0.0042	<0.029	0.052	<0.011	0.041	<0.031	3	<0.021	5.4
Pentachlorophenol	2,300	1	**<2.0 J**	<0.97 J	<0.95 J	<0.47	<0.36	<0.96	**<2**	<0.98	<0.96	<0.96	<0.96	<0.96	<0.25
Phenanthrene	>S	-	0.0033 J	0.0033 J	0.0035 J	<0.0043	<0.02	<0.005	0.013 J	<0.02	<0.004	<0.0048	0.052	<0.012	0.34
Pyrene	>S	1,100	0.0032 J	<0.02	0.0072 J	0.0041 J	<0.02	<0.01	0.011 J	<0.02	0.0059 J	<0.02	<0.015	<0.014	<0.1
Zinc	36,000	11,000	8.3 B	2.1 B	7.7 B	3.2 B	<10	5 J	6.3 J	2.3 J	<10	<10	<10	12.2	<0.02
Total Napthalenes[b]		350	0.0370	0.0440	0.0280	0.0268	0.0242	0.0490	0.0569	0.0137	0.0454	0.0364	3.08	0.0248	5.70
Benzo(a)pyrene TEQ for cPAHs[c]		0.12	0.0230	0.0300	0.0106	0.00528	0.0302	0.0144	0.0245	0.0300	0.0249	0.0302	0.0108	0.0189	**0.151**
		0.12	0.0118	0.0150	0.00924	0.00428	0.0151	0.00720	0.0145	0.0150	0.0129	0.0151	0.00979	0.01873	0.0755

[a]Seven carcinogenic PAHs (cPAHs)
[b]Total napthalenes includes a sum of 2-methylnaphthalene and naphthalene; calculated value
[c]Benzo(a)pyrene TEQ for cPAHs were calculated by summing the project of concentrations and toxicity equivalent factors per Chapter 173-340 WAC Eq. 720-1; full- and half-detection limit values were substituted to compute the upper and lower TEQ values, respectively.
[d] Values presented for benzo(a)pyrene and pentachlorophenol are MCL values, other values provided are MTCA Method C concentration values.

Table 1. Analytical Results for Groundwater Samples (continued). MW-3I

		Location ID	MW-31	MW-3I	MW-3I	MW-3I	MW-3I	MW-31	MW-31	MW-3I	MW-3I	MW-3I	MW-3I	MW-3I	MW-3I
		Sample Date	5/23/2003	9/8/2003	11/25/2003	2/26/2004	5/20/2004	8/17/2004	11/22/2004	2/23/2005	5/26/2005	8/26/2005	12/7/2005	2/27/2006	9/9/2008
		Sample ID	MW-31-0503	MW-3I-0903	MW-31-1103	MW-3I-0204	MW-3I-0504	MW-3I-0804	MW-31-1104	MW-3I-0205	MW-3I-0505	MW-3I-0805	MW-31-1205	MW-3I-0206	0908PSR04
Chemical (µg/L)	ACLs (µg/L)	MCL or MTCA Method C[d] (µg/L)													
2-Methylnaphthalene	-	70	0.026	0.016 J	<0.0095	0.034	0.016 J	0.021	0.0089 J	<0.0082	0.019 J	0.011 J	0.33	0.011 J	<0.10
Acenaphthene	>S	2,100	0.016 J	0.054	0.034	0.026	0.03	0.062	0.03	0.036	0.073	0.046	0.31	0.037	0.21
Acenaphthylene	700	-	0.02	0.076	0.1	0.0072 J	0.017 J	0.064	0.051	0.059	0.046	0.085	0.049	0.05	<0.10
Anthracene	900	11,000	0.016 J	0.1	0.1	0.035	0.08	0.16	0.15	0.31	0.13	0.19	0.14	0.18	<0.10
Benzo(a)anthracene[a]	3	-	0.011 J	0.011 J	0.017 J	0.016 J	0.019 J	0.019 J	0.017 J	0.021	0.016 J	0.017 J	0.019 J	0.016 J	<0.10
Benzo(a)pyrene[a]	3	0.2	<0.0054	0.0027 J	0.0059 J	0.0031 J	0.0057 J	<0.0083	<0.021	0.013 J	0.0093 J	0.0065 J	<0.020	0.0057	<0.10
Benzo(b)fluoranthene[a]	>S	-	0.0060 J	0.0053 J	0.0080 J	0.0068 J	0.010 J	<0.01	<0.021	0.017 J	0.014 J	0.014 J	<0.020	0.0083	<0.10
Benzo(g,h,i)perylene[a]	0.016	-	0.0038 J	<0.020	0.0061 J	<0.021	<0.020	<0.0053	0.006 J	0.0097 J	0.0071 J	<0.020	0.0055 J	0.0054	<0.10
Benzo(k)fluoranthene[a]	3	-	<0.0043	0.0018 J	0.0057 J	0.0034 J	0.0065 J	<0.0091	<0.021	0.013 J	0.0060 J	<0.020	<0.020	0.005	<0.10
Chrysene[a]	3	-	0.012 J	0.014 J	0.016 J	0.017 J	0.017 J	<0.024	0.012 J	0.025	0.018 J	0.016 J	0.02 J	0.017 J	<0.10
Dibenz(a,h)anthracene[a]	>S	-	<0.0017	<0.020	0.0023 J	<0.021	<0.020	<0.02	0.0035 J	<0.021	0.0018 J	<0.020	<0.020	<0.0036	<0.10
Dibenzofuran	190	70	<0.020	0.013 J	0.010 J	0.012 J	0.016 J	0.039	0.0079 J	0.014 J	0.016 J	0.011 J	0.13	0.016 J	<0.10
Fluoranthene	100	140	0.052	0.082 J	0.072	0.12	0.11	0.059	0.051	0.1	0.049	0.065	0.063	0.083	<0.10
Fluorene	200	140	0.019 J	0.022	0.024	0.037	0.039	0.054	0.019 J	0.035	0.03	0.02	0.11	0.036	<0.10
Indeno(1,2,3-cd)pyrene[a]	0.1	-	<0.0040	<0.020 J	<0.0069	<0.021	0.0026 J	<0.0059	0.0090 J	0.0084 J	0.0085 J	0.0026 J	0.0060 J	<0.005	<0.1
Naphthalene	7,700	-	0.029	0.073	0.063	0.078	0.045	<0.11	0.058	0.054	0.12	0.11	12	0.15	4.4
Pentachlorophenol	490	1	**<2.0 J**	<0.96 J	<0.94 J	<0.59	**<1.7**	<0.96	**<2.1**	**<1.1**	**<1.0**	<0.96	<0.96	<0.96	<0.25
Phenanthrene	400	-	0.046	0.047	0.056	0.17	0.12	0.095	0.041	0.053	0.046	0.046	0.14	0.062	<0.10
Pyrene	>S	1,100	0.049	0.083	0.11	0.13	0.08	0.086	0.076	0.15	0.055	0.1	0.093	0.1	<0.10
Zinc	7,700	11,000	18.1	4.6 B	12.1	12.9	<12.1	5 J	1550	8.0 J	11.4	8.8 J	35.9	1,960	0.08
Total Napthalenes[b]		350	0.0550	0.0890	0.0725	0.112	0.0610	0.131	0.0669	0.0622	0.139	0.121	12.3	0.160	4.50
Benzo(a)pyrene TEQ for cPAHs[c]		0.12	0.00822	0.00865	0.0101	0.0101	0.0117	0.0149	0.0283	0.0213	0.0141	0.0140	0.0287	0.0097	**0.151**
		0.12	0.00502	0.00665	0.00971	0.00799	0.01068	0.00842	0.0157	0.0202	-	0.01202	0.0157	0.00923	0.0755

[a]Seven carcinogenic PAHs (cPAHs)
[b]Total napthalenes includes a sum of 2-methylnaphthalene and naphthalene; calculated value
[c]Benzo(a)pyrene TEQ for cPAHs were calculated by summing the project of concentrations and toxicity equivalent factors per Chapter 173-340 WAC Eq. 720-1;
full- and half-detection limit values were substituted to compute the upper and lower TEQ values, respectively.
[d] Values presented for benzo(a)pyrene and pentachlorophenol are MCL values, other values provided are MTCA Method C concentration values.

Table 1. Analytical Results for Groundwater Samples (continued). MW-3S

		Location ID	MW-31	MW-3I	MW-3I	MW-3I	MW-3I	MW-31	MW-31	MW-3I	MW-3I	MW-3I	MW-3I	MW-3I	MW-3I
		Sample Date	5/23/2003	9/8/2003	11/25/2003	2/26/2004	5/20/2004	8/17/2004	11/22/2004	2/23/2005	5/26/2005	8/26/2005	12/7/2005	2/27/2006	9/9/2008
		Sample ID	MW-31-0503	MW-3I-0903	MW-31-1103	MW-3I-0204	MW-3I-0504	MW-3I-0804	MW-31-1104	MW-3I-0205	MW-3I-0505	MW-3I-0805	MW-31-1205	MW-3I-0206	0908PSR04
Chemical (µg/L)	ACLs (µg/L)	MCL or MTCA Method C[d] (µg/L)													
2-Methylnaphthalene	-	70	0.026	0.016 J	<0.0095	0.034	0.016 J	0.021	0.0089 J	<0.0082	0.019 J	0.011 J	0.33	0.011 J	<0.10
Acenaphthene	>S	2,100	0.016 J	0.054	0.034	0.026	0.03	0.062	0.03	0.036	0.073	0.046	0.31	0.037	0.21
Acenaphthylene	700	-	0.02	0.076	0.1	0.0072 J	0.017 J	0.064	0.051	0.059	0.046	0.085	0.049	0.05	<0.10
Anthracene	900	11,000	0.016 J	0.1	0.1	0.035	0.08	0.16	0.15	0.31	0.13	0.19	0.14	0.18	<0.10
Benzo(a)anthracene[a]	3	-	0.011 J	0.011 J	0.017 J	0.016 J	0.019 J	0.019 J	0.017 J	0.021	0.016 J	0.017 J	0.019 J	0.016 J	<0.10
Benzo(a)pyrene[a]	3	0.2	<0.0054	0.0027 J	0.0059 J	0.0031 J	0.0057 J	<0.0083	<0.021	0.013 J	0.0093 J	0.0065 J	<0.020	0.0057	<0.10
Benzo(b)fluoranthene[a]	>S	-	0.0060 J	0.0053 J	0.0080 J	0.0068 J	0.010 J	<0.01	<0.021	0.017 J	0.014 J	0.014 J	<0.020	0.0083	<0.10
Benzo(g,h,i)perylene[a]	0.016	-	0.0038 J	<0.020	0.0061 J	<0.021	<0.020	<0.0053	0.006 J	0.0097 J	0.0071 J	<0.020	0.0055 J	0.0054	<0.10
Benzo(k)fluoranthene[a]	3	-	<0.0043	0.0018 J	0.0057 J	0.0034 J	0.0065 J	<0.0091	<0.021	0.013 J	0.0060 J	<0.020	<0.020	0.005	<0.10
Chrysene[a]	3	-	0.012 J	0.014 J	0.016 J	0.017 J	0.017 J	<0.024	0.012 J	0.025	0.018 J	0.016 J	0.02 J	0.017 J	<0.10
Dibenz(a,h)anthracene[a]	>S	-	<0.0017	<0.020	0.0023 J	<0.021	<0.020	<0.02	0.0035 J	<0.021	0.0018 J	<0.020	<0.020	<0.0036	<0.10
Dibenzofuran	190	70	<0.020	0.013 J	0.010 J	0.012 J	0.016 J	0.039	0.0079 J	0.014 J	0.016 J	0.011 J	0.13	0.016 J	<0.10
Fluoranthene	100	140	0.052	0.082 J	0.072	0.12	0.11	0.059	0.051	0.1	0.049	0.065	0.063	0.083	<0.10
Fluorene	200	140	0.019 J	0.022	0.024	0.037	0.039	0.054	0.019 J	0.035	0.03	0.02	0.11	0.036	<0.10
Indeno(1,2,3-cd)pyrene[a]	0.1	-	<0.0040	<0.020 J	<0.0069	<0.021	0.0026 J	<0.0059	0.0090 J	0.0084 J	0.0085 J	0.0026 J	0.0060 J	<0.005	<0.1
Naphthalene	7,700	-	0.029	0.073	0.063	0.078	0.045	<0.11	0.058	0.054	0.12	0.11	12	0.15	4.4
Pentachlorophenol	490	1	**<2.0 J**	<0.96 J	<0.94 J	<0.59	**<1.7**	<0.96	**<2.1**	**<1.1**	**<1.0**	<0.96	<0.96	<0.96	<0.25
Phenanthrene	400	-	0.046	0.047	0.056	0.17	0.12	0.095	0.041	0.053	0.046	0.046	0.14	0.062	<0.10
Pyrene	>S	1,100	0.049	0.083	0.11	0.13	0.08	0.086	0.076	0.15	0.055	0.1	0.093	0.1	<0.10
Zinc	7,700	11,000	18.1	4.6 B	12.1	12.9	<12.1	5 J	1550	8.0 J	11.4	8.8 J	35.9	1,960	0.08
Total Napthalenes[b]		350	0.0550	0.0890	0.0725	0.112	0.0610	0.131	0.0669	0.0622	0.139	0.121	12.3	0.160	4.50
Benzo(a)pyrene TEQ for cPAHs[c]		0.12	0.00822	0.00865	0.0101	0.0101	0.0117	0.0149	0.0283	0.0213	0.0141	0.0140	0.0287	0.0097	**0.151**
		0.12	0.00502	0.00665	0.00971	0.00799	0.01068	0.00842	0.0157	0.0202	-	0.01202	0.0157	0.00923	0.0755

[a]Seven carcinogenic PAHs (cPAHs)
[b]Total napthalenes includes a sum of 2-methylnaphthalene and naphthalene; calculated value
[c]Benzo(a)pyrene TEQ for cPAHs were calculated by summing the project of concentrations and toxicity equivalent factors per Chapter 173-340 WAC Eq. 720-1;
full- and half-detection limit values were substituted to compute the upper and lower TEQ values, respectively.
[d] Values presented for benzo(a)pyrene and pentachlorophenol are MCL values, other values provided are MTCA Method C concentration values.

Table 1. Analytical Results for Groundwater Samples (continued). MW-6SR

		Location ID	MW-31	MW-3I	MW-3I	MW-3I	MW-3I	MW-31	MW-31	MW-3I	MW-3I	MW-3I	MW-3I	MW-3I	MW-3I
		Sample Date	5/23/2003	9/8/2003	11/25/2003	2/26/2004	5/20/2004	8/17/2004	11/22/2004	2/23/2005	5/26/2005	8/26/2005	12/7/2005	2/27/2006	9/9/2008
		Sample ID	MW-31-0503	MW-3I-0903	MW-31-1103	MW-3I-0204	MW-3I-0504	MW-3I-0804	MW-31-1104	MW-3I-0205	MW-3I-0505	MW-3I-0805	MW-31-1205	MW-3I-0206	0908PSR04
Chemical (µg/L)	ACLs (µg/L)	MCL or MTCA Method C[d] (µg/L)													
2-Methylnaphthalene	-	70	0.026	0.016 J	<0.0095	0.034	0.016 J	0.021	0.0089 J	<0.0082	0.019 J	0.011 J	0.33	0.011 J	<0.10
Acenaphthene	>S	2,100	0.016 J	0.054	0.034	0.026	0.03	0.062	0.03	0.036	0.073	0.046	0.31	0.037	0.21
Acenaphthylene	700	-	0.02	0.076	0.1	0.0072 J	0.017 J	0.064	0.051	0.059	0.046	0.085	0.049	0.05	<0.10
Anthracene	900	11,000	0.016 J	0.1	0.1	0.035	0.08	0.16	0.15	0.31	0.13	0.19	0.14	0.18	<0.10
Benzo(a)anthracene[a]	3	-	0.011 J	0.011 J	0.017 J	0.016 J	0.019 J	0.019 J	0.017 J	0.021	0.016 J	0.017 J	0.019 J	0.016 J	<0.10
Benzo(a)pyrene[a]	3	0.2	<0.0054	0.0027 J	0.0059 J	0.0031 J	0.0057 J	<0.0083	<0.021	0.013 J	0.0093 J	0.0065 J	<0.020	0.0057	<0.10
Benzo(b)fluoranthene[a]	>S	-	0.0060 J	0.0053 J	0.0080 J	0.0068 J	0.010 J	<0.01	<0.021	0.017 J	0.014 J	0.014 J	<0.020	0.0083	<0.10
Benzo(g,h,i)perylene[a]	0.016	-	0.0038 J	<0.020	0.0061 J	<0.021	<0.020	<0.0053	0.006 J	0.0097 J	0.0071 J	<0.020	0.0055 J	0.0054	<0.10
Benzo(k)fluoranthene[a]	3	-	<0.0043	0.0018 J	0.0057 J	0.0034 J	0.0065 J	<0.0091	<0.021	0.013 J	0.0060 J	<0.020	<0.020	0.005	<0.10
Chrysene[a]	3	-	0.012 J	0.014 J	0.016 J	0.017 J	0.017 J	<0.024	0.012 J	0.025	0.018 J	0.016 J	0.02 J	0.017 J	<0.10
Dibenz(a,h)anthracene[a]	>S	-	<0.0017	<0.020	0.0023 J	<0.021	<0.020	<0.02	0.0035 J	<0.021	0.0018 J	<0.020	<0.020	<0.0036	<0.10
Dibenzofuran	190	70	<0.020	0.013 J	0.010 J	0.012 J	0.016 J	0.039	0.0079 J	0.014 J	0.016 J	0.011 J	0.13	0.016 J	<0.10
Fluoranthene	100	140	0.052	0.082 J	0.072	0.12	0.11	0.059	0.051	0.1	0.049	0.065	0.063	0.083	<0.10
Fluorene	200	140	0.019 J	0.022	0.024	0.037	0.039	0.054	0.019 J	0.035	0.03	0.02	0.11	0.036	<0.10
Indeno(1,2,3-cd)pyrene[a]	0.1	-	<0.0040	<0.020 J	<0.0069	<0.021	0.0026 J	<0.0059	0.0090 J	0.0084 J	0.0085 J	0.0026 J	0.0060 J	<0.005	<0.1
Naphthalene	7,700	-	0.029	0.073	0.063	0.078	0.045	<0.11	0.058	0.054	0.12	0.11	12	0.15	4.4
Pentachlorophenol	490	1	**<2.0 J**	<0.96 J	<0.94 J	<0.59	**<1.7**	<0.96	**<2.1**	**<1.1**	**<1.0**	<0.96	<0.96	<0.96	<0.25
Phenanthrene	400	-	0.046	0.047	0.056	0.17	0.12	0.095	0.041	0.053	0.046	0.046	0.14	0.062	<0.10
Pyrene	>S	1,100	0.049	0.083	0.11	0.13	0.08	0.086	0.076	0.15	0.055	0.1	0.093	0.1	<0.10
Zinc	7,700	11,000	18.1	4.6 B	12.1	12.9	<12.1	5 J	1550	8.0 J	11.4	8.8 J	35.9	1,960	0.08
Total Napthalenes[b]		350	0.0550	0.0890	0.0725	0.112	0.0610	0.131	0.0669	0.0622	0.139	0.121	12.3	0.160	4.50
Benzo(a)pyrene TEQ for cPAHs[c]		0.12	0.00822	0.00865	0.0101	0.0101	0.0117	0.0149	0.0283	0.0213	0.0141	0.0140	0.0287	0.0097	**0.151**
		0.12	0.00502	0.00665	0.00971	0.00799	0.01068	0.00842	0.0157	0.0202	-	0.01202	0.0157	0.00923	0.0755

[a]Seven carcinogenic PAHs (cPAHs)

[b]Total napthalenes includes a sum of 2-methylnaphthalene and naphthalene; calculated value

[c]Benzo(a)pyrene TEQ for cPAHs were calculated by summing the project of concentrations and toxicity equivalent factors per Chapter 173-340 WAC Eq. 720-1; full- and half-detection limit values were substituted to compute the upper and lower TEQ values, respectively.

[d] Values presented for benzo(a)pyrene and pentachlorophenol are MCL values, other values provided are MTCA Method C concentration values.

Table 1. Analytical Results for Groundwater Samples (continued). MW-3D

Chemical (µg/L)	ACLs (µg/L)	Location ID Sample Date Sample ID MCL or MTCA Method C[d] (µg/L)	MW-3D 9/9/2008 0908PSR03
2-Methylnaphthalene	-	70	0.032
Acenaphthene	>S	2,100	0.099
Acenaphthylene	2,700	-	<0.030
Anthracene	>S	11,000	<0.030
Benzo(a)anthracene[a]	>S	-	<0.030
Benzo(a)pyrene[a]	>S	0.2	<0.030
Benzo(b)fluoranthene[a]	>S	-	<0.030
Benzo(g,h,i)perylene[a]	0.06	-	<0.030
Benzo(k)fluoranthene[a]	12	-	<0.030
Chrysene[a]	>S	-	<0.030
Dibenz(a,h)anthracene[a]	>S	-	<0.030
Dibenzofuran	750	70	0.044
Fluoranthene	>S	140	<0.030
Fluorene	790	140	<0.030
Indeno(1,2,3-cd)pyrene[a]	0.39	-	<0.030
Naphthalene	30,000	-	2.3
Pentachlorophenol	1,900	1	<.25
Phenanthrene	1,000	-	<0.030
Pyrene	>S	1,100	<0.030
Zinc	30,000	11,000	<0.01
Total Napthalenes[b]		350	2.33
Benzo(a)pyrene TEQ for cPAHs[c]		0.12 0.12	0.0453 0.0227

[a]Seven carcinogenic PAHs (cPAHs)

[b]Total napthalenes includes a sum of 2-methylnaphthalene and naphthalene; calculated value

[c]Benzo(a)pyrene TEQ for cPAHs were calculated by summing the project of concentrations and toxicity equivalent factors per Chapter 173-340 WAC Eq. 720-1; full- and half-detection limit values were substituted to compute the upper and lower TEQ values, respectively.

[d] Values presented for benzo(a)pyrene and pentachlorophenol are MCL values, other values provided are MTCA Method C concentration values.

Table 1. Analytical Results for Groundwater Samples (continued). MW-11IR

		Location ID	MW-11IR	MW-11IR	MW-11IR	MW-11IR	MW-11IR	MW-11IR	MW-11IR	MW-11IR	MW-11IR	MW-11IR	MW-11IR	MW-11IR	MW-11IR
		Sample Date	9/9/2003	11/25/2003	2/25/2004	5/19/2004	8/16/2004	11/23/2004	2/23/2005	5/27/2005	8/26/2005	8/26/2005	12/8/05	2/27/2006	9/10/2008
		Sample ID	MW-11IR-0903	MW-11IR-1103	MW-11IR-0204	MW-11IR-0504	MW-11IR-0804	MW-11IR-1104	MW-11IR-0205	MW-11IR-0505	MW-11IR-0805	MW-21-0805	MW-11IR-1205	MW-11IR-0206	0908PSR11
Chemical (µg/L)	ACLs (µg/L)	MCL or MTCA Method C[d] (µg/L)													
2-Methylnaphthalene	-	70	0.19	0.69	3.1	<0.020	0.37	0.053	0.047	0.056	0.035	0.035	0.12	0.027	0.72
Acenaphthene	>S	2,100	80	57	87	0.48	39	49	34	34	21	22	8.7	5.1	0.48
Acenaphthylene	700	-	2.8	1.3	1	0.051	0.67	0.38	0.36	0.31	0.19	0.22	0.094	0.31	0.2
Anthracene	900	11,000	5.3 J	0.88	2.6	0.26	4.6	1.9	1.5	3	2.4	2.2	1.7	1.4	<0.20
Benzo(a)anthracene[a]	3	-	1.1	0.63	0.65	0.22	2.1	0.41	0.44	0.59	0.6	0.59	0.53	0.85	0.64
Benzo(a)pyrene[a]	3	0.2	**0.2**	0.1	0.052	0.083	**0.47**	0.034	0.078	0.025	0.038	0.034	0.031	0.12	**<0.20**
Benzo(b)fluoranthene[a]	>S	-	0.25	0.14	0.1	0.12	0.61	0.068	0.15	0.043	0.061	0.052	0.043	0.16	<0.20
Benzo(g,h,i)perylene[a]	0.016	-	**0.037**	**0.027**	0.0087 J	0.013 J	**0.083**	0.0085 J	0.015 J	0.02	0.0041 J	0.0043 J	<0.020	**0.022**	<0.20
Benzo(k)fluoranthene[a]	3	-	0.25	0.11	0.088	0.13	0.54	0.019 J	0.086	0.038	0.046	0.05	0.045	0.13	<0.20
Chrysene[a]	3	-	0.91	0.44	0.41	0.28	1.3	0.12	0.3	0.3	0.33	0.28	0.26	0.4	0.36
Dibenz(a,h)anthracene[a]	>S	-	0.016 J	0.0084 J	0.0029 J	0.0035 J	0.034	<0.020	0.0051 J	<0.020	<0.020	<0.020	<0.020	<0.012	<0.20
Dibenzofuran	190	70	44	33	44	<0.020	25	28	22	23	16	16	8.7	2.3	<0.20
Fluoranthene	100	140	23	14	21	2.3	14	15	14	17	15	15	15	15	12
Fluorene	200	140	60	29	61	0.031	28	29	2	7.4	0.95	0.97	0.24	0.16	0.24
Indeno(1,2,3-cd)pyrene[a]	0.1	-	0.056	0.035	0.011 J	0.016 J	**0.12**	<0.020	0.022	<0.020	0.0054 J	0.0046 J	0.0038 J	0.031	<0.2
Naphthalene	7,700	-	0.059	66	110	<0.0038	17	0.44	1.5	0.77	0.55	0.53	3.9	1.8	14
Pentachlorophenol	490	1	<0.96 J	<0.95 J	<0.51	**<1.4**	<0.96	**<2.0**	**<1.1**	<0.96	<0.96	<0.96	<0.96	<0.96	<.25
Phenanthrene	400	-	22	1.7	100	0.044	44	74	46	55	38	38	5.9	0.48	0.28
Pyrene	>S	1,100	14	7.4	14	0.52	10	8.3	8	11	8.9	9.1	8.5	7.1	7.3
Zinc	7,700	11,000	4.1 B	2.9 B	<10	<10	6 J	<10	24	<10	<10.0	<10.0	35	1370	<.02
Total Napthalenes[b]		350	0.249	66.7	113	0.0238	17.4	0.493	1.55	0.826	0.585	0.565	4.02	1.83	14.7
Benzo(a)pyrene TEQ for cPAHs[c]		0.12	**0.376**	**0.197**	**0.141**	**0.135**	**0.823**	0.0889	**0.151**	0.0991	**0.115**	0.108	0.0978	**0.242**	**0.348**
		0.12	-	-	-	-	-	0.0869	-	0.0971	0.1135	0.1075	0.0968	**0.242**	**0.208**

[a]Seven carcinogenic PAHs (cPAHs)
[b]Total napthalenes includes a sum of 2-methylnaphthalene and naphthalene; calculated value
[c]Benzo(a)pyrene TEQ for cPAHs were calculated by summing the project of concentrations and toxicity equivalent factors per Chapter 173-340 WAC Eq. 720-1; full- and half-detection limit values were substituted to compute the upper and lower TEQ values, respectively.
[d] Values presented for benzo(a)pyrene and pentachlorophenol are MCL values, other values provided are MTCA Method C concentration values.

Table 1. Analytical Results for Groundwater Samples (continued). MW-15SR

		Location ID	MW-15-SR	MW-15SR	MW-15SR	MW-15SR	MW-15SR	MW-15SR	MW-15SR	MW-15SR	MW-1 5SR	MW-15SR	MW-15SR	MW-15SR	MW-15SR
		Sample Date	5/24/2003	9/9/2003	11/24/2003	2/25/2004	5/19/2004	8/16/2004	11/23/2004	2/23/2005	5/27/2005	8/26/2005	12/8/2005	2/28/2006	9/10/2008
		Sample ID	MW-15-SR-0503	MW-15SR-0903	MW-15SR-1103	MW-15SR-0204	MW-15SR-0504	MW-15SR-0804	MW-15SR-1104	MW-15SR-0205	MW-15SR-0505	MW-15SR-0805	MW-1 5SR-1 20	MW-15SR-1205	0908PSR13
Chemical (µg/L)	ACLs (µg/L)	MCL or MTCA Method C[d] (µg/L)													
2-Methylnaphthalene	-	70	10	9	0.036	1.8	0.26	0.38	0.027	0.13	0.51	5.6	1.5	0.21	8.1
Acenaphthene	>S	2,100	52	68	53	39 J	14	11	22	5.4	3.1	15	6.5	2	17
Acenaphthylene	3,330	-	0.48	0.65	0.56	0.7	0.15	0.17	0.23	0.13	0.21	0.8	0.21	0.076	<1.0
Anthracene	>S	11,000	8.7	7.1	6	9.9	2.7	3.3	5	3.6	2.7	18	4.7	1.7	8.5
Benzo(a)anthracene[a]	>S	-	0.95	0.59	0.42	2.4	0.15	0.3	0.5	0.55	0.34	1.2 J	0.64	0.22	<1.0
Benzo(a)pyrene[a]	>S	0.2	**0.21**	0.15 J	0.06	**0.9**	0.019 J	0.064	0.12	0.14	0.1	0.095 J	**0.22**	0.062	**<1.0**
Benzo(b)fluoranthene[a]	>S	-	0.29	0.2	0.075	1.2	0.027	0.09	0.19	0.19	0.18	0.16 J	0.33	0.076	<1.0
Benzo(g,h,i)perylene[a]	(0.09)/(>S)	-	0.033	0.042 J	0.0079 J	**0.2**	<0.020	<0.014	0.029	0.026 J	0.035	0.028 J	0.058	<0.014	<1.0
Benzo(k)fluoranthene[a]	14	-	0.2	0.14 J	0.043	0.93	0.012 J	0.057	0.061	0.16	0.087	0.11 J	0.21	0.06	<1.0
Chrysene[a]	>S	-	0.9	0.71	0.29	2.7	0.13	0.34	0.44	0.89	0.53	0.61 J	1	0.3	<1.0
Dibenz(a,h)anthracene[a]	>S	-	<0.014	0.021 J	0.0028 J	0.09	0.0035 J	<0.0063	0.013 J	0.0091 J	0.0087 J	0.0079 J	0.027	<0.0079	<1.0
Dibenzofuran	880	70	33	43	31	22 J	6.5	5.6	11	1.6	1.2	7.2	3	1.2	7.6
Fluoranthene	>S	140	12	12	7.7	17	2.9	4.3	9.4	4.5	4.8	20	7.1	2.7	19
Fluorene	930	140	39	44	33	29 J	5.6	3.4	12	2.5	2.3	13	5.5	2.5	16
Indeno(1,2,3-cd)pyrene[a]	0.47	-	0.057	0.067 J	0.012 J	0.29	0.0059 J	0.021	0.032	0.039	0.043	0.031 J	0.074	0.026	<1.0
Naphthalene	>S	-	46	310	5.5	17	1.6	3.1	<2.5	0.81	4.5	44	20	1.6	41
Pentachlorophenol	2,300	1	**<2.0 J**	**3.2 J**	<0.95 J	**310 J**	**34 J**	**56**	**4.3 J**	**14**	**64**	**270**	**75 J**	**5.1**	**220**
Phenanthrene	>S	-	44	50	25	36 J	5.6	3.6	16	2.5	2.1	9.2	5.9	2.6	25
Pyrene	>S	1,100	7.2	5	4.4	14	1.6	2.4	5.7	3	2.7	12	4.8	1.5	10
Zinc	36,000	11,000	7.5 B	<10.0	<10	2.2 B	<10	2 J	<10	<10.0	<10	<10.0	<10	<10	<.01
Total Napthalenes[b]		350	56.0	319	5.54	18.8	1.86	3.48	2.53	0.940	5.01	49.6	21.5	1.81	49.1
Benzo(a)pyrene TEQ for cPAHs[c]		0.12	**0.370**	**0.259**	**0.118**	**1.42**	0.0401	**0.115**	**0.204**	**0.244**	**0.171**	**0.252**	**0.358**	0.104	**1.51**
		0.12	**0.369**	-	-	-	-	0.1145	-	-	-	-	-	0.1036	**0.755**

[a]Seven carcinogenic PAHs (cPAHs)
[b]Total napthalenes includes a sum of 2-methylnaphthalene and naphthalene; calculated value
[c]Benzo(a)pyrene TEQ for cPAHs were calculated by summing the project of concentrations and toxicity equivalent factors per Chapter 173-340 WAC Eq. 720-1; full- and half-detection limit values were substituted to compute the upper and lower TEQ values, respectively.
[d] Values presented for benzo(a)pyrene and pentachlorophenol are MCL values, other values provided are MTCA Method C concentration values.

Table 1. Analytical Results for Groundwater Samples (continued). MW-16I

Chemical (µg/L)	ACLs (µg/L)	Location ID Sample Date Sample ID MCL or MTCA Method C[d] (µg/L)	MW-161 12/7/2005 MW-161-1205	MW-161 2/28/2006 MW-1 61-0206	MW-161 2/28/2006 MW-16IR-0206	MW-16I 9/9/2008 0908PSR08	MW-16I 9/9/2008 0908PSR09
2-Methylnaphthalene	-	70	34	29	34	0.61	0.67
Acenaphthene	>S	2,100	21	16	18	8.5	7.6
Acenaphthylene	700	-	0.25	0.37	0.39	<0.50	<0.50
Anthracene	900	11,000	0.22	0.25	0.25	<0.50	<0.50
Benzo(a)anthracene[a]	3	-	0.021	0.056 J	0.059 J	<0.50	<0.50
Benzo(a)pyrene[a]	3	0.2	<0.020	0.03 J	0.026 J	**<0.50**	**<0.50**
Benzo(b)fluoranthene[a]	>S	-	<0.020	0.034 J	0.032 J	<0.50	<0.50
Benzo(g,h,i)perylene[a]	0.016	-	<0.020	**0.029 J**	**0.028 J**	<0.50	<0.50
Benzo(k)fluoranthene[a]	3	-	<0.020	0.028 J	0.026 J	<0.50	<0.50
Chrysene[a]	3	-	0.020 J	0.046 J	0.046 J	<0.50	<0.50
Dibenz(a,h)anthracene[a]	>S	-	<0.020	0.029 J	0.029 J	<0.50	<0.50
Dibenzofuran	190	70	4.7	3.6	3.8	0.67	<0.50
Fluoranthene	100	140	0.72	0.67	0.66	0.63	0.56
Fluorene	200	140	6.2	4.7	5	1.5	1.2
Indeno(1,2,3-cd)pyrene[a]	0.1	-	<0.020	0.029 J	0.028 J	<0.50	<0.50
Naphthalene	7,700	-	1400	890	1100	34	38
Pentachlorophenol	490	1	<0.96	**<4.8**	**<4.8**		<0.25
Phenanthrene	400	-	4.1	3.3	3.2	<2.0	1.6
Pyrene	>S	1,100	0.36	0.32	0.32	0.50	<0.50
Zinc	7,700	11,000	<10	<10	<10	<0.02	<0.02
Total Napthalenes[b]		350	**1434**	**919**	**1134**	34.6	38.7
Benzo(a)pyrene TEQ for cPAHs[c]		0.12 0.12	0.0303 0.0163	0.0481 -	0.0439 -	**0.755** **0.378**	**0.755** **0.378**

[a]Seven carcinogenic PAHs (cPAHs)
[b]Total napthalenes includes a sum of 2-methylnaphthalene and naphthalene; calculated value
[c]Benzo(a)pyrene TEQ for cPAHs were calculated by summing the project of concentrations and toxicity equivalent factors per Chapter 173-340 WAC Eq. 720-1; full- and half-detection limit values were substituted to compute the upper and lower TEQ values, respectively.
[d] Values presented for benzo(a)pyrene and pentachlorophenol are MCL values, other values provided are MTCA Method C concentration values.

Table 1. Analytical Results for Groundwater Samples (continued). RW-1S

		Location ID	RW-1S	RW-1S	RW-1S	RW-1S	RW-1S	RW-1S	RW-1S	RW-1S	RW-1S	RW-1S	RW-1S	RW-1S	RW-1S	RW-1S
		Sample Date	5/23/2003	9/8/2003	11/25/2003	2/26/2004	5/20/2004	5/20/2004	8/17/2004	11/23/2004	2/24/2005	5/27/2005	8/26/2005	12/7/2005	2/28/2006	9/9/2008
		Sample ID	RW-1S-0503	RW-1S-0903	RW-1S-1103	RW-1S-0204	RW-1S-0504	RW-100S0504	RW-1S-0804	RW-1S-1104	RW-1S-0205	RW-1S-0505	RW-1S-0805	RW-1S-1205	MW-1S-0206	0908PSR07
Chemical (µg/L)	ACLs (µg/L)	MCL or MTCA Method C[d] (µg/L)														
2-Methylnaphthalene	-	70	11	5.7	3.6 J	0.59 J	6.8	5.9	5.1	1.4	1.2	0.37	0.89	0.48	0.4	<5.0
Acenaphthene	>S	2,100	270	370	360 J	290 J	300	280	180	480	370	310	380	350	260	360
Acenaphthylene	3,330	-	6.1	4.6	8.8 J	6.4 J	6	6.2	6.4	6.8	4.8 J	2.7	4.7	5.7	7.4	<5.0
Anthracene	>S	11,000	8	14	14 J	9.2 J	8.7	9.7	13	14	11 J	11	11	11	10	12
Benzo(a)anthracene[a]	>S	-	0.5 J	0.88	1.2 J	1.2 J	0.43	0.46	0.96	0.92	0.54 J	1.1	0.47 J	0.72	0.68	<5.0
Benzo(a)pyrene[a]	>S	0.2	0.16 J	**0.49**	**0.5 J**	**0.55 J**	0.14 J	0.15 J	**0.94**	**0.63**	0.13 J	**1.3**	**0.32 J**	**1.1**	**0.86**	**<5.0**
Benzo(b)fluoranthene[a]	>S	-	0.23 J	0.39	0.53 J	0.62 J	0.18 J	0.19 J	1	0.7	0.18 J	2.1	0.30 J	1.2	0.84	<5.0
Benzo(g,h,i)perylene[a]	(0.09)/(>S)	-	0.065 J	**0.24**	**0.19 J**	**0.44 J**	0.054 J	0.048 J	**0.64**	**0.56**	0.039 J	**0.85**	**0.24 J**	**0.78**	**0.93**	<5.0
Benzo(k)fluoranthene[a]	14	-	0.15 J	0.5	0.39 J	0.48 J	0.073 J	0.12 J	0.46	0.2	0.11 J	<0.039	0.11 J	0.26	0.21	<5.0
Chrysene[a]	>S	-	0.3 J	0.71	0.81 J	1 J	0.28	0.33	0.78	0.72	0.42 J	0.84	0.28 J	0.59	0.51	<5.0
Dibenz(a,h)anthracene[a]	>S	-	0.019	0.095 J	0.048 J	0.1 J	<0.20	<0.20	0.12	0.12	<0.097	0.077	0.040 J	0.13 J	0.12	<5.0
Dibenzofuran	880	70	**86**	**180**	**130 J**	**100 J**	**83**	**83**	**92**	**140**	**170**	**150**	**160**	**140**	**110**	**150**
Fluoranthene	>S	140	14	20	24 J	21 J	18	18	22	22	23	21	17	22	15	29
Fluorene	930	140	93	**170**	**130 J**	**130 J**	77	79	85	**140**	**160**	**140**	**160**	**140**	110	**170**
Indeno(1,2,3-cd)pyrene[a]	0.47	-	0.10 J	0.3	0.27 J	**0.51 J**	0.09 J	0.064 J	**0.82**	0.48	0.051 J	**1.2**	0.26 J	**0.91**	**1**	<5.0
Naphthalene	>S	-	1100	1200	810 J	180 J	740	670	510	660	870	380	710	670	57	86
Pentachlorophenol	2,300	1	**430 J**	**220 J**	**93 J**	**22 J**	**220 J**	**250 J**	**31**	**4.0 J**	**1.3 J**	**2.3**	**17**	**2.9 J**	**13**	**7**
Phenanthrene	>S	-	52	140	63 J	48 J	33	35	59	65	90	89	110	89	55	160
Pyrene	>S	1,100	7.2	9.7	15 J	13 J	8.9	9.1	12	11	12	12	9.2	11	7.8	17
Zinc	36,000	11,000	2 B	12.6	8.7 B	3.2 B	<6.5	<2.8	4 J	13.8	2.2 J	12.9	<10.0	<10	18.7	0.02
Total Napthalenes[b]		350	**1111**	**1206**	**814**	**181**	**747**	**676**	**515**	**661**	**871**	**380**	**711**	**670**	57.4	91.0
Benzo(a)pyrene TEQ for cPAHs[c]		0.12	**0.263**	**0.714**	**0.752**	**0.851**	**0.240**	**0.257**	**1.284**	**0.879**	**0.232**	**1.76**	**0.441**	**1.428**	**1.150**	**7.55**
		0.12	-	-	-	-	**0.230**	**0.247**	-	-	**0.227**	**1.758**	-	-	-	**3.78**

[a]Seven carcinogenic PAHs (cPAHs)

[b]Total napthalenes includes a sum of 2-methylnaphthalene and naphthalene; calculated value

[c]Benzo(a)pyrene TEQ for cPAHs were calculated by summing the project of concentrations and toxicity equivalent factors per Chapter 173-340 WAC Eq. 720-1; full- and half-detection limit values were substituted to compute the upper and lower TEQ values, respectively.

[d] Values presented for benzo(a)pyrene and pentachlorophenol are MCL values, other values provided are MTCA Method C concentration values.

Table 1. Analytical Results for Groundwater Samples (continued). RW-12S

		Location ID	RW-12S	RW-12S	RW-12S	RW-12S	RW-12S	RW-12S	RW-12S	RW-12S	RW-12S	RW-12S	RW-12S	RW-12S	RW-12S	RW-12S
		Sample Date	5/28/2003	9/9/2003	11/24/2003	2/25/2004	5/20/2004	8/17/2004	11/23/2004	2/24/2005	5/27/2005	5/27/2005	8/25/2005	12/8/2005	2/28/2006	9/11/2008
		Sample ID	RW-12S-0503	RW-12S-0903	RW-12S-1103	RW-12S-0204	RW-12S0504	RW-12S-0804	RW-12S-1104	RW-12S-0205	RW-12S-0505	RW-2S-0505	RW-12S-0805	RW-12S-1205	MW-12S-0206	0908PSR15
Chemical (µg/L)	ACLs (µg/L)	MCL or MTCA Method C[d] (µg/L)														
2-Methylnaphthalene	-	70	0.1	0.18	<0.010	0.016 J	0.11	0.12	0.042	0.022 J	0.02 J	0.024	0.084	0.29	0.0089 J	0.034
Acenaphthene	>S	2,100	0.63	0.97	0.29	0.6	0.91	1.1	0.79	0.7	0.54	0.66	0.88	1	0.4	0.34
Acenaphthylene	3,330	-	0.05	0.1	0.012 J	0.018 J	0.08	0.082	0.055	0.034	0.028	0.036	0.066	0.047	<0.031	<0.030
Anthracene	>S	11,000	0.16	0.43	0.12	0.21	0.75	0.56	0.41	0.38	0.26	0.32	0.56	0.34	0.26	0.30
Benzo(a)anthracene[a]	>S	-	0.061	0.08	0.06	0.068	0.081	0.089	0.072	0.071	0.06	0.079	0.087	0.091	0.08	0.34
Benzo(a)pyrene[a]	>S	0.2	<0.012	<0.011 J	0.0039 J	0.0061 J	0.013 J	<0.012	<0.020	0.0049 J	0.0084 J	0.0099 J	<0.020	0.017 J	<0.01	0.076
Benzo(b)fluoranthene[a]	>S	-	0.021	0.018 J	0.01 J	0.016 J	0.015 J	<0.016	<0.020	0.015 J	0.014 J	0.02 J	0.016 J	0.039	0.016 J	0.094
Benzo(g,h,i)perylene[a]	(0.09)/(>S)	-	<0.01	0.0054 J	<0.019	<0.020	<0.020	<0.0074	<0.020	<0.023	0.0069 J	0.0088 J	<0.020	0.01 J	<0.0066	<0.030
Benzo(k)fluoranthene[a]	14	-	<0.012	0.014 J	0.0044 J	0.011 J	0.013 J	<0.012	<0.020	0.0061 J	0.011 J	0.014 J	0.011 J	<0.020	0.013 J	0.091
Chrysene[a]	>S	-	0.07	0.081	0.055	0.068	0.07	<0.084	0.042	0.072	0.062	0.076	0.083	0.089	0.069	0.34
Dibenz(a,h)anthracene[a]	>S	-	<0.0053	<0.020	<0.019	<0.020	<0.020	<0.02	<0.020	<0.023	0.003 J	0.0031 J	<0.020	<0.020	<0.0018	<0.030
Dibenzofuran	880	70	0.028	0.057	0.014 J	0.018 J	0.041	0.051	0.026	0.019 J	0.013 J	0.014 J	0.041	0.15	0.0081 J	0.094
Fluoranthene	>S	140	0.86	1.4	0.77	1.1	1.3	1.5	1.5	1.2	1	1.3	2	1.2	1	1.7
Fluorene	930	140	0.23	0.36	0.11	0.23	0.35	0.43	0.24	0.22	0.16	0.2	0.38	0.33	0.15	0.2
Indeno(1,2,3-cd)pyrene[a]	0.47	-	<0.011	0.0049 J	<0.019	0.0038 J	<0.020	<0.02	<0.020	<0.023	0.0072 J	0.0089 J	<0.020	<0.020	<0.0081	<0.030
Naphthalene	>S	-	4.6	7.5	0.52	0.79	4.7	4.9	2.4	1.6	1.3	1.7	4.3	11	0.21	<0.26
Pentachlorophenol	2,300	1	**<2.0 J**	0.45 J	<0.95 J	<0.49	<0.48	<0.96	**<2.0**	**1.2**	0.16 J	<0.96	<0.96	<0.96	<0.96	<.25
Phenanthrene	>S	-	0.067	0.11	0.016 J	0.043	0.1	0.11	0.073	<0.027	0.02	0.026	0.12	0.15	0.024	0.16
Pyrene	>S	1,100	0.79	0.96	0.65	1	1	1	1.2	0.96	0.73	0.89	1.5	1.1	0.73	1.8
Zinc	36,000	11,000	<10.0	<10.0	2.2 B	<10	<10	2 J	<10	2.3 J	<10	<10	<10.0	11.2	<10	<.01
Total Napthalenes[b]		350	4.70	7.68	0.530	0.806	4.81	5.02	2.44	1.62	1.32	1.72	4.38	11.3	0.219	0.294
Benzo(a)pyrene TEQ for cPAHs[c]		0.12	0.0237	0.0255	0.0157	0.0187	0.0286	0.0285	0.0356	0.0194	0.0185	0.0232	0.0362	0.0369	0.0226	**0.138**
		0.12	0.0163	0.0190	0.01379	0.01766	0.0266	0.0187	0.0216	0.01713	-	-	0.0242	0.0344	0.0171	**0.1349**

[a]Seven carcinogenic PAHs (cPAHs)

[b]Total napthalenes includes a sum of 2-methylnaphthalene and naphthalene; calculated value

[c]Benzo(a)pyrene TEQ for cPAHs were calculated by summing the project of concentrations and toxicity equivalent factors per Chapter 173-340 WAC Eq. 720-1;
full- and half-detection limit values were substituted to compute the upper and lower TEQ values, respectively.

[d] Values presented for benzo(a)pyrene and pentachlorophenol are MCL values, other values provided are MTCA Method C concentration values.

Table 1. Analytical Results for Groundwater Samples (continued). MW-15D

		Location ID	MW-15D
		Sample Date	9/11/2008
		Sample ID	0908PSR14
Chemical (µg/L)	ACLs (µg/L)	MCL or MTCA Method C[d] (µg/L)	
2-Methylnaphthalene	-	70	1.9
Acenaphthene	>S	2,100	25
Acenaphthylene	2,700	-	<0.50
Anthracene	>S	11,000	6.9
Benzo(a)anthracene[a]	>S	-	3.6
Benzo(a)pyrene[a]	>S	0.2	**0.72**
Benzo(b)fluoranthene[a]	>S	-	1.0
Benzo(g,h,i)perylene[a]	0.06	-	<0.50
Benzo(k)fluoranthene[a]	12	-	0.90
Chrysene[a]	>S	-	3.6
Dibenz(a,h)anthracene[a]	>S	-	<0.50
Dibenzofuran	750	70	2.4
Fluoranthene	>S	140	33
Fluorene	790	140	3.6
Indeno(1,2,3-cd)pyrene[a]	0.39	-	<0.50
Naphthalene	30,000	-	9.0
Pentachlorophenol	1,900	1	<.26
Phenanthrene	1,000	-	8.8
Pyrene	>S	1,100	21
Zinc	30,000	11,000	<0.02
Total Napthalenes[b]	-	350	10.9
Benzo(a)pyrene TEQ for cPAHs[c]		0.12	**1.41**
		0.12	**1.36**

[a]Seven carcinogenic PAHs (cPAHs)
[b]Total napthalenes includes a sum of 2-methylnaphthalene and naphthalene; calculated value
[c]Benzo(a)pyrene TEQ for cPAHs were calculated by summing the project of concentrations and toxicity equivalent factors per Chapter 173-340 WAC Eq. 720-1; full- and half-detection limit values were substituted to compute the upper and lower TEQ values, respectively.
[d] Values presented for benzo(a)pyrene and pentachlorophenol are MCL values, other values provided are MTCA Method C concentration values.

Table 1. Analytical Results for Groundwater Samples (continued). MW-14I

Chemical (μg/L)	ACLs (μg/L)	Location ID / Sample Date / Sample ID / MCL or MTCA Method C[d] (μg/L)	MW-14I 5/2/2003 MW-14I-0503	MW-14I 9/8/2003 MW-14I-0903	MW-14I 9/8/2003 MW-14I-0903	MW-141 11/26/2003 MW-14S-1103	MW-14I 2/25/2004 MW-14I-0204	MW-14I 5/20/2004 MW-14I-0504	MW-141 8/17/2004 MW-141-0804	MW-141 11/22/2004 MW-141-1104	MW-141 2/23/2005 MW-141-0205	MW-141 5/27/2005 MW-141-0505	MW-141 8/25/2005 MW-141-0805	MW-141 12/7/2005 MW-141-12-5	MW-141 2/27/2005 MW-141-0206	MW-14I 9/9/2008 0908PSR06
2-Methylnaphthalene	-	**70**	**220**	**340**	**370**	**500**	**750**	**500**	**190**	**470**	**76 J**	**500**	**510**	**700**	**860**	**1,600**
Acenaphthene	>S	2,100	160	360	390	230	360	230	110	380	390	550	590	810	780	**8,500**
Acenaphthylene	700	-	5.3	9.6	9.1	5.2	8.3	5.7	4	9.4	6.9	13	13	17	20 J	<250
Anthracene	900	11,000	14	15	15	5.5	20	17	5.8	22	27	78	49	62	52 J	**1,300**
Benzo(a)anthracene[a]	3	-	1.0 J	1	1.1	0.24	2	0.17 J	0.38	**10**	**19**	**60**	**48**	**74**	**81 J**	**990**
Benzo(a)pyrene[a]	3	0.2	**0.21 J**	**0.34**	**0.36**	0.085 J	**0.66**	0.036 J	**0.29**	**3.8**	**7.5**	**24**	**17**	**26**	**30 J**	**360**
Benzo(b)fluoranthene[a]	>S	-	0.26 J	0.43	0.45	0.082 J	0.88	0.042 J	0.14	6.6	10	30	24	33	40 J	470
Benzo(g,h,i)perylene[a]	0.016	-	**0.054 J**	**0.097 J**	**0.10 J**	0.19	**0.19 J**	<0.20	**0.037 J**	**1.1**	**2.1**	**6.6**	**4.5**	**6.8**	**7.4 J**	<250
Benzo(k)fluoranthene[a]	3	-	0.27 J	0.3	0.35	0.048 J	0.67	0.028 J	0.12	2.4	**7.3**	**23**	**16**	**34**	**27 J**	**430**
Chrysene[a]	3	-	0.88 J	1.1	1.1	0.18 J	1.8	0.12 J	0.32	**9.4**	**16**	**54**	**45**	**69**	**68 J**	**990**
Dibenz(a,h)anthracene[a]	>S	-	0.026 J	0.034 J	0.041 J	0.19	0.099 J	<0.20	0.017 J	0.59 J	0.82	2.9	2	2.4 J	4.6 J	<250
Dibenzofuran	190	70	**90**	**210**	**220**	**130**	**160**	53	66	**290**	**230**	**370**	**350**	**480**	**470**	**4,500**
Fluoranthene	100	140	14	16	15	5.1	20	9.8	6.4	60	**110**	**370**	**280**	**440**	**410 J**	**6,200**
Fluorene	200	140	91	**160**	**170**	73	**170**	66	50	**160**	**170**	**460**	**280**	**430**	**380 J**	**5,400**
Indeno(1,2,3-cd)pyrene[a]	0.1	-	0.092 J	0.14 J	0.18 J	0.035 J	0.24 J	<0.20	0.048 J	1.3	2.7	7.4	5.5	9.2	10 J	<250
Naphthalene	7,700	-	2500	5900	6300	**7800**	**9800**	7400	3700	**8600**	**11000**	7300	6700	**8400**	**9200**	**15,000**
Pentachlorophenol	490	1	**120 J**	**5900 J**	**5400 J**	**23 J**	**21 J**	**9.1 J**	**1.7 J**	**6.4 J**	**9.9 J**	**2.4 J**	**<96**	**<48**	**<48**	**23**
Phenanthrene	400	-	110	120	130	85	170	84	46	280	330	**890**	**820**	**1200**	**1200**	**16,000**
Pyrene	>S	1,100	8	7.6	7.5	2.4	13	3.5	3.4	38	75	260	190	270	240 J	**4,100**
Zinc	7,700	11,000	163	11.9	5.1 B	30.9	25.9	<3.7	5.1 J	70.7	4.7 J	36	17.1	<10	5800	<.01
Total Napthalenes[b]		350	**2720**	**6240**	**6670**	**8300**	**10550**	**7900**	**3890**	**9070**	**11076**	**7800**	**7210**	**9100**	**10060**	**16600**
Benzo(a)pyrene TEQ for cPAHs[c]		0.12	**0.384**	**0.541**	**0.583**	**0.146**	**1.07**	0.101	**0.364**	**5.98**	**11.6**	**36.9**	**27.0**	**42.0**	**46.9**	**609**
		0.12	-	-	-	-	-	0.0812	-	-	-	-	-	-	-	**584**

[a]Seven carcinogenic PAHs (cPAHs)
[b]Total napthalenes includes a sum of 2-methylnaphthalene and naphthalene; calculated value
[c]Benzo(a)pyrene TEQ for cPAHs were calculated by summing the project of concentrations and toxicity equivalent factors per Chapter 173-340 WAC Eq. 720-1; full- and half-detection limit values were substituted to compute the upper and lower TEQ values, respectively.
[d] Values presented for benzo(a)pyrene and pentachlorophenol are MCL values, other values provided are MTCA Method C concentration values.

Table 1. Analytical Results for Groundwater Samples (continued). MW-15IR

Chemical (µg/L)	ACLs (µg/L)	Location ID Sample Date Sample ID MCL or MTCA Method C[d] (µg/L)	MW-15-IR 5/24/2003 MW-15-IR-0503	MW-15IR 9/9/2003 MW-15IR-0903	MW-15IR 11/24/2003 MW-15IR-1103	MW-15IR 2/25/2004 MW-15IR-0204	MW-15IR 5/19/2004 MW-15IR-0504	MW-15IR 8/16/2004 MW-15IR-0804	MW-15IR 11/23/2004 MW-15IR-1104	MW-15IR 2/24/2005 MW-15IR-0205	MW-15IR 5/27/2005 MW-15IR-0505	MW-15IR 8/26/2005 MW-15IR-0805	MW-15IR 12/8/2005 MW-15IR-1205	MW-15IR 2/28/2006 MW-15IR-0206	MW-15IR 9/10/2008 0908PSR12
2-Methylnaphthalene	-	70	0.063	**230**	**180**	**370**	**190**	**98**	**160**	**300**	**110**	**98**	**230**	**92**	**300**
Acenaphthene	>S	2,100	4.4	230	190	320	180	60	220	240	91	130	280	250	350
Acenaphthylene	700	-	0.12	2.6	2.9	3.7	2.4	1.5	3.9	2.8	2.2	1.7	2.9	2.7	<80
Anthracene	900	11,000	0.21	8.2	6.8	11	7.9	5.2	6.9	8.8	7	4.3	8.4	10	<80
Benzo(a)anthracene[a]	3	-	0.3	0.2	0.15	0.5	0.31	0.38	1	0.78	**4.3**	1	1.6	**7.4**	<80
Benzo(a)pyrene[a]	3	0.2	0.038	0.035 J	0.018 J	**0.2 J**	0.044 J	0.11	**<0.96**	0.16	**1.1**	**0.29**	**0.45**	**2**	**<80**
Benzo(b)fluoranthene[a]	>S	-	0.081	0.055 J	0.02	0.22 J	0.060 J	0.12	<0.96	0.22	1.5	0.38	0.62	2.5	<80
Benzo(g,h,i)perylene[a]	0.016	-	0.0099 J	<0.097	0.0047 J	**0.16 J**	<0.20	**0.037 J**	<0.96	**0.036 J**	**0.25**	**0.067 J**	**0.090 J**	**0.45**	<80
Benzo(k)fluoranthene[a]	3	-	0.053	0.051 J	0.015 J	0.20 J	0.056 J	0.11	<0.96	0.2	1.3	0.29	0.41	2.2	<80
Chrysene[a]	3	-	0.34	0.21	0.12	0.43	0.25	0.36	0.66 J	0.67	**3.9**	0.92	1.4	5.2	<80
Dibenz(a,h)anthracene[a]	>S	-	0.0044	0.0095 J	<0.019	0.15 J	<0.20	0.017 J	<0.96	0.0098 J	0.079 J	0.025 J	0.031 J	0.34	<80
Dibenzofuran	190	70	2.1	**160**	**98**	**130**	**72**	37	**110**	**130**	54	57	**130**	**85**	**190**
Fluoranthene	100	140	3.8	8.2	6.1	14	8.9	5.2	10	12	26	8.4 J	18	53	**140**
Fluorene	200	140	1.7	130	97	**150**	74	32	99	120	52	60	130	120	**210**
Indeno(1,2,3-cd)pyrene[a]	0.1	-	0.014	0.024 J	<0.0060	**0.15 J**	<0.20	0.043 J	<0.96	0.048 J	**0.32**	**0.11**	**0.11**	**0.67**	<80
Naphthalene	7,700	-	0.053	4000	3600	5000	2900	2100	4500	5700	3800	3200	4600	1400	4,600
Pentachlorophenol	490	1	**<2.0 J**	**2.6 J**	**<9.5 J**	**10 J**	**8.8 J**	**<4.8**	**<4.8**	**11**	**<11**	**<4.8**	**<4.8**	**2.8 J**	**3.9**
Phenanthrene	400	-	0.17	98	69	130	65	27	89	100	80	50	110	120	**410**
Pyrene	>S	1,100	2	3.7	3.5	7.7	4.2	2.7	6	6.4	15	5.2 J	11	27	97
Zinc	7,700	11,000	19.3	<10.0	4.7 B	<10.0	<13.1	27.5	<10.0	<10.0	4140	<10.0	<10.0	8.8 J	<.02
Total Napthalenes[b]		350	0.116	**4230**	**3780**	**5370**	**3090**	**2198**	**4660**	**6000**	**3910**	**3298**	**4830**	**1492**	**4900**
Benzo(a)pyrene TEQ for cPAHs[c]		0.12	0.0866	0.0711	0.0402	**0.326**	**0.129**	**0.181**	**1.45**	**0.292**	**1.89**	**0.480**	**0.741**	**3.36**	**121**
		0.12	-	-	0.0390	-	0.1091	-	**0.779**	-	-	-	-	-	**60.4**

[a]Seven carcinogenic PAHs (cPAHs)

[b]Total napthalenes includes a sum of 2-methylnaphthalene and naphthalene; calculated value

[c]Benzo(a)pyrene TEQ for cPAHs were calculated by summing the project of concentrations and toxicity equivalent factors per Chapter 173-340 WAC Eq. 720-1;
full- and half-detection limit values were substituted to compute the upper and lower TEQ values, respectively.

[d] Values presented for benzo(a)pyrene and pentachlorophenol are MCL values, other values provided are MTCA Method C concentration values.

Table 1. Analytical Results for Groundwater Samples (continued). MW-14S

		Location ID	MW-14S	MW-14S	MW-14S	MW-14S	MW-14S	MW-14S	MW-14S	MW-14S	MW-14S	MW-14S	MW-14S	MW-14S	MW-14S	MW-14S	MW-14S
		Sample Date	5/23/2003	9/8/2003	11/26/2003	2/25/2004	2/25/2004	5/20/2004	8/17/2004	11/22/2004	11/22/2004	2/23/2005	5/26/2005	8/25/2005	12/7/2005	2/27/2006	9/9/2008
		Sample ID	MW-14S-0503	MW-14S-0903	MVvM 41-1 103	MW-14S-0204	Duplicate1-0204	MW-14S-0504	MW-14S-0804	MW-04S-1104	MW-14S-1104	MW-14S-0205	MW-14S-0505	MW-14S-0805	MW-14S-1205	MW-14S-0206	0908PSR05
Chemical (µg/L)	ACLs (µg/L)	MCL or MTCA Method C[d] (µg/L)															
2-Methylnaphthalene	-	70	**350**	**590**	**390**	**320 J**	**310 J**	**280**	**160**	**240**	**210**	**340**	**200**	**290**	**220**	**190 J**	69
Acenaphthene	>S	2,100	290	290	440	400 J	390 J	330	180	450	420	390	300	370	370	340 J	380
Acenaphthylene	3,330	-	9.2	7.3	11	8.4 J	8.2 J	9.3	8.5	9.2	9	9.5	8.3	11	8.8	8.5	<40
Anthracene	>S	11,000	23	4.3	30	21 J	21 J	22	24	16	15	23	17	20	12	16	<40
Benzo(a)anthracene[a]	>S	-	0.9 J	0.22	0.92	0.57 J	0.65 J	0.44	0.32	0.68 J	0.86 J	0.43	0.33 J	0.35 J	0.87 J	0.49	<40
Benzo(a)pyrene[a]	>S	0.2	**0.21 J**	0.19 J	**0.23**	0.18 J	**0.21 J**	0.11 J	0.071 J	**<1.1**	**<1.0**	0.059 J	**<0.39**	**<2.0**	**<0.20**	0.13 J	**<40**
Benzo(b)fluoranthene[a]	>S	-	0.28 J	0.063 J	0.27	0.25 J	0.29 J	0.16 J	0.086 J	<1.1	<1.0	0.11 J	<0.39	<2.0	0.16 J	0.15 J	<40
Benzo(g,h,i)perylene[a]	(0.09)/(>S)	-	0.031 J	**<0.2**	0.052 J	**0.11 J**	**0.13 J**	0.053 J	<0.096	<1.1	<1.0	<0.42	<0.39	<2.0	0.049 J	0.06 J	<40
Benzo(k)fluoranthene[a]	14	-	0.24 J	0.033 J	0.19	0.18 J	0.23 J	0.14 J	0.072 J	<1.1	<1.0	0.068 J	<0.39	<2.0	0.11 J	0.11 J	<40
Chrysene[a]	>S	-	0.85 J	0.19 J	0.73	0.56 J	0.71 J	0.43	0.4	0.55 J	0.55 J	0.45	0.3 J	0.29 J	0.53 J	0.43	<40
Dibenz(a,h)anthracene[a]	>S	-	<0.017	<0.20	<0.19	0.091 J	0.11 J	<0.20	<0.096	<1.1	<1.0	<0.42	<0.39	<2.0	<0.20	0.076 J	<40
Dibenzofuran	880	70	**160**	**170**	**240**	**160 J**	**160 J**	**200**	**110**	**230**	**210**	**240**	**170**	**210**	**180**	**210 J**	**190**
Fluoranthene	>S	140	13	8.2	16	12 J	12 J	12	10	11	11	13	9.2	10	12	12	40
Fluorene	930	140	130	93	**200**	**160 J**	**160 J**	**150**	87	**160**	**150**	**190**	**150**	**170**	**140**	**160 J**	**150**
Indeno(1,2,3-cd)pyrene[a]	0.47	-	0.057 J	0.032 J	0.077 J	0.13 J	0.14 J	0.074 J	0.023 J	<1.1	<1.0	<0.42	<0.39	<2.0	<0.20	0.077 J	<40
Naphthalene	>S	-	4300	9000	5900	5200 J	5200 J	5000	2900	6200	6000	6100	5400	5600	4440	4800 J	3,200
Pentachlorophenol	2,300	1	**3200 J**	**42 J**	**2500 J**	**2700 J**	**2600 J**	**2200**	**1400**	**41000 J**	**34000 J**	**1400**	**1600**	**1500**	**560 J**	**410**	**26J**
Phenanthrene	>S	-	100	120	140	130 J	130 J	93	64	120	110	150	110	120	130	130 J	160
Pyrene	>S	1,100	8.3	3.4	9.8	7.9 J	8 J	6.2	5.4	6.2	5.8	6.7	4.8	5.5	6.5	5.6	<40
Zinc	36,000	11,000	12.5	<10.0	445	19.4 J	17.2	27.9	75.1	24.9	17.2	46.1	25.9	68.4 N	<10	<10	<.02
Total Napthalenes[b]		350	**4650**	**9590**	**6290**	**5520**	**5510**	**5280**	**3060**	**6440**	**6210**	**6440**	**5600**	**5890**	**4660**	**4990**	**3269**
Benzo(a)pyrene TEQ for cPAHs[c]		0.12	**0.368**	**0.247**	**0.402**	**0.308**	**0.359**	**0.216**	**0.135**	**1.61**	**1.49**	**0.208**	**0.582**	**2.84**	**0.359**	**0.225**	**60.4**
		0.12	**0.367**	**0.237**	**0.393**	-	-	**0.206**	**0.1299**	**0.844**	**0.792**	**0.166**	**0.309**	**1.44**	**0.239**	-	**30.2**

[a]Seven carcinogenic PAHs (cPAHs)

[b]Total napthalenes includes a sum of 2-methylnaphthalene and naphthalene; calculated value

[c]Benzo(a)pyrene TEQ for cPAHs were calculated by summing the project of concentrations and toxicity equivalent factors per Chapter 173-340 WAC Eq. 720-1;
full- and half-detection limit values were substituted to compute the upper and lower TEQ values, respectively.

[d] Values presented for benzo(a)pyrene and pentachlorophenol are MCL values, other values provided are MTCA Method C concentration values.

Attachment 7

Statistical Trend Analysis and Results

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Attachment 7, Statistical Trend Analysis and Results

The statistical trend analysis approach described in this section is consistent with the approach used by RETEC/AECOM previously with an important exception. The first step in our revised approach includes treatment of non-detect and outlier values.

Treatment of Non-Detect Values

The statistical software program ProUCL (EPA 2007) was used to visually inspect the distribution and impacts of both non-detect values and statistical outliers on each parameter dataset for each monitoring well. Outliers were operationally defined as 2x the third quantile value, flagged, and not included in subsequent analyses. Data sets containing more than 50 percent non-detect values were eliminated from further evaluation in the trend analysis. Data sets containing more than 50 percent detect values were then subject to a Goodness-of-Fit evaluation for gamma, normal, and lognormal distributions. For data sets where none of the distributions fit well, a normal distribution was assumed. Next, Regression on Order Statistics (ROS) estimates were used to substitute for the non-detect values and replicate sample values were averaged prior to performing the statistical tests. Negative values resulting from ROS substitution were truncated to zero.

Statistical Tests

Prior to testing for trends, seasonality of the data was tested using the Kruskal-Wallis test (Gilbert, 1987) at the 5 percent significance level using a statistical software program (MiniTab 2006). The Kruskal-Wallis test is a non-parametric test that determines differences in groupings of data. For the PSR site this indicates whether there is a consistent change in concentrations in one of the four quarters of yearly data. A finding of seasonality would indicate that other factors, such as seasonal groundwater flow direction changes, could mask any long-term trends in groundwater PAH or zinc concentrations at the monitoring locations. Subsequent trend testing was not performed for analytes that exhibited seasonality.

The existence of a significant trend was determined using the Mann-Kendall trend analysis (Gilbert, 1987), which is a non-parametric procedure that is used to estimate trend when seasonality does not exist. Results are reported at the 5% level of significance. The Mann-Kendall test looks for trends in ranking of the data, rather than in the absolute value for the data. If the Mann-Kendall test indicate a significant trend, then the Sen's Slope Estimator (Gilbert, 1987) was used to calculate rate of change over time of PAH and zinc concentrations in each well. Both the Mann-Kendall and Sen’s Slope Estimator tests were computed manually in spreadsheets using the algorithms described in Gilbert, 1987. Critical statistic values for the Mann-Kendall tests were obtained from Table A.21 in Hollander and Wolfe, 1973.

Comprehensive results of the statistical tests are presented in Table E. Tables 4 and 5 in the main text include a summary of the statistical test results in comparison with those previously presented by RETEC 2005.

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Table E. Seasonality and Trend Test Analysis, MW-3S

Date	Sample ID	Quarter	2-Methylnaphthalene	Acenaphthene	Acenaphthylene	Anthracene	Benzo(a)anthracene	Benzo(a)pyrene	Benzo(b)fluoranthene	Benzo(g,h,i)perylene	Benzo(k)fluoranthene	Chrysene	Dibenz(a,h)anthracene	Dibenzofuran	Fluoranthene	Fluorene	Indeno(1,2,3-cd)pyrene	Naphthalene	Pentachlorophenol	Phenanthrene	Pyrene	Zinc
05/23/03	MW-3S-0503	1	0.0054	0.0039	0.0019	0.0093										0.0032				0.0083	0.0086	
9/8/2003	MW-3S-0903	2	0.001207	0.0030	0.002894	0.0100										0.0037				0.0043	0.0071	
11/25/03	MW-3S-1103*	3	0	0.0063	0.003878	0.0110										0.0065				0.0043	0.0115	
02/26/04	MW-3S-0204	4	0.012	0.0069	0.004862	0.0180										0.0077				0.00349	0.0110	
05/20/04	MW-3S-0504	1	0.0035	0.0052	0.0032	0.0300										0.0080				0.025	0.0200	
08/17/04	MW-3S-0804*	2	0.003626	0.0041	0.0019	0.0205										0.0044				0.004611	0.0164	
11/22/04	MW-3S-1104	3	0.0061	0.0220	0.0048	0.0250										0.0160				0.033	0.0320	
02/23/05	MW-3S-0205	4	0.001207	0.0041	0.0055	0.0640										0.0105				0.089	0.0420	
05/26/05	MW-3S-0505	1	0.0056	0.016239	0.0036	0.031										0.006192				0.002005	0.013	
08/26/05	MW-3S-0805	2	0.0078	0.0080	0.0044	0.0390										0.0085				0.008167	0.0240	
12/07/05	MW-3S-1205	3			0.0077	0.0230															0.0390	
2/272006	MW-3S-0206	4	0.0044	0.0030	0.003878	0.0076										0.0031				0.051	0.0190	
09/09/08	0908PSR02	2	0.014	0.0390	0.003878	0.0026										0.0100				0.01	0.0180	
Kruskall-Wallis Seasonality		test statistic	0.59	1.78	7.01	0.48										1.49				1.19	1.80	
		critical statistic	7.81	7.81	7.81	7.81										7.81				7.81	7.81	
		significant at %5 level?	No	No	No	No										No				No	No	
Mann-Kendall Trend																						
		test statistic	23	20	26	14										20				36	32	
		critical statistic	25	25	28	28										25				25	28	
		significant at %5 level?	No	No	No	No										No				**Yes**	**Yes**	
Sen's Slope Estimator		Slope (µg/L/yr)																			0.00344	

Notes:
* duplicate data averaged
Blank columns indicate that more than 50% of the values were non-detect for the analyte, and such, no meaningful trend information may be obtained.
Missing values in an otherwise populated column indicates that the corresponding value was identified as an outlier and removed from the trend analysis.
Sen's Slope was not calculated when the Mann-Kendall Trend test found no significant trend.

Table E. Seasonality and Trend Test Analysis, MW-11S

Date	Sample ID	Quarter	2-Methylnaphthalene	Acenaphthene	Acenaphthylene	Anthracene	Benzo(a)anthracene	Benzo(a)pyrene	Benzo(b)fluoranthene	Benzo(g,h,i)perylene	Benzo(k)fluoranthene	Chrysene	Dibenz(a,h)anthracene	Dibenzofuran	Fluoranthene	Fluorene	Indeno(1,2,3-cd)pyrene	Naphthalene	Pentachlorophenol	Phenanthrene	Pyrene	Zinc
05/24/03	MW-11S-0503	1		0.002805		0.011	0.0021		0.0028						0.0052							8.3
09/09/03	MW-11S-0903	2		0.003743		0.033	0.002167		0.002823						0.002819							2.1
11/24/03	MW-11S-1103	3		0.003743		0.011	0.0041		0.0084						0.0081							7.7
02/24/04	MW-11S-0204	4		0.004681		0.014	0.0022		0.0041						0.000782							3.2
05/19/04	MW-11S-0504	1		0.0027		0.06	0.004177		0.006408						0.007619							10
08/16/04	MW-11S-0804	2		0.0045		0.056	0.003954		0.006993						0.006377							5
11/23/04	MW-11S-1104	3		0.004		0.06	0.0095		0.013						0.014							6.3
02/24/05	MW-11S-0205	4		0.0031		0.062	0.005909		0.009495						0.004							2.3
05/27/05	MW-11S-0505	1		0.0028		0.049	0.0034		0.0034						0.0097							1.8
08/26/05	MW-11S-0805	2		0.0031		0.038	0.00792		0.01308						0.011838							4.4
12/08/05	MW-11S-1205	3		0.006		0.026	0.0066		0.0083						0.024							6.7
02/28/06	MW-11S-0206	4		0.003743		0.047	0.0092		0.018						0.02							12.2
09/10/08	0908PSR10	2				0.038917																0
Kruskal-Wallis Seasonality		test statistic		6.98		0.57	3.21		4.38						3.21							3.16
		critical statistic		7.81		7.81	7.81		7.81						7.81							7.81
		significant at %5 level?		No		No	No		No						No							No
Mann-Kendall Trend		test statistic		6		16	40		38						36							-2
		critical statistic		25		28	25		25						25							28
		significant at %5 level?		No		No	**Yes**		**Yes**						**Yes**							No
Sen's Slope Estimator		Slope (µg/L/yr)					0.00218		0.00395						0.00534							

Notes:
* duplicate data averaged
Blank columns indicate that more than 50% of the values were non-detect for the analyte, and such, no meaningful trend information may be obtained.
Missing values in an otherwise populated column indicates that the corresponding value was identified as an outlier and removed from the trend analysis.
Sen's Slope was not calculated when the Mann-Kendall Trend test found no significant trend.

Table E. Seasonality and Trend Test Analysis, MW-15S

Date	Sample ID	Quarter	2-Methylnaphthalene	Acenaphthene	Acenaphthylene	Anthracene	Benzo(a)anthracene	Benzo(a)pyrene	Benzo(b)fluoranthene	Benzo(g,h,i)perylene	Benzo(k)fluoranthene	Chrysene	Dibenz(a,h)anthracene	Dibenzofuran	Fluoranthene	Fluorene	Indeno(1,2,3-cd)pyrene	Naphthalene	Pentachlorophenol	Phenanthrene	Pyrene	Zinc
05/24/03	MW-15-SR-050	1	10	52.00	0.48	8.70	0.95	0.21	0.29	0.033	0.2	0.9	0.006985	33	12.0	39.0	0.057	46	0	44	7.2	
09/09/03	MW-15SR-0903	2	9	68.00	0.65	7.10	0.59	0.15	0.2	0.042	0.14	0.71	0.021	43	12.0	44.0	0.067		3.2	50	5.0	
11/24/03	MW-15SR-1103	3	0.036	53.00	0.56	6.00	0.42	0.06	0.075	0.0079	0.043	0.29	0.0028	31	7.7	33.0	0.012	5.5	0	25	4.4	
02/25/04	MW-15SR-0204	4	1.8	39.00	0.7	9.90	2.40							22	17.0	29.0		17		36	14.0	
05/19/04	MW-15SR-0504	1	0.26	14.00	0.15	2.70	0.15	0.019	0.027	0.007828	0.012	0.13	0.0035	6.5	2.9	5.6	0.0059	1.6	34	5.6	1.6	
08/16/04	MW-15SR-0804	2	0.38	11.00	0.17	3.30	0.30	0.064	0.09	0.002777	0.057	0.34	0.001522	5.6	4.3	3.4	0.021	3.1	56	3.6	2.4	
11/23/04	MW-15SR-1104	3	0.027	22.00	0.23	5.00	0.50	0.12	0.19	0.029	0.061	0.44	0.013	11	9.4	12.0	0.032	1.314343	4.3	16	5.7	
02/23/05	MW-15SR-0205	4	0.13	5.40	0.13	3.60	0.55	0.14	0.19	0.026	0.16	0.89	0.0091	1.6	4.5	2.5	0.039	0.81	14	2.5	3.0	
05/27/05	MW-15SR-0505	1	0.51	3.10	0.21	2.70	0.34	0.1	0.18	0.035	0.087	0.53	0.0087	1.2	4.8	2.3	0.043	4.5	64	2.1	2.7	
08/26/05	MW-15SR-0805	2	5.6	15.00	0.8	18.00	1.20	0.095	0.16	0.028	0.11	0.61	0.0079	7.2	20.0	13.0	0.031	44		9.2	12.0	
12/08/05	MW-1 5SR-1 20	3	1.5	6.50	0.21	4.70	0.64	0.22	0.33	0.058	0.21	1	0.027	3	7.1	5.5	0.074	20	75	5.9	4.8	
02/28/06	MW-1 5SR-1 20	4	0.21	2.00	0.076	1.70	0.22	0.062	0.076	0.011899	0.06	0.3	0.001522	1.2	2.7	2.5	0.026	1.6	5.1	2.6	1.5	
09/10/08	0908PSR13	2	8.1	17	0.364	8.5	0.43					0.516		7.6	19	16		41	120	25	10	
Kruskal-Wallis Seasonality																						
	test statistic		5.09	1.93	2.17	1.81	0.73	0.2	0.32	0.74	0.08	0.03	1.18	1.59	2.49	1.56	0.08	2.51	0.73	1.39	1.25	
	critical statistic		7.81	7.81	7.81	7.81	7.81	7.81	7.81	7.81	7.81	7.81	7.81	7.81	7.81	7.81	7.81	7.81	7.81	7.81	7.81	
	significant at %5 level?		No	No	No	No	No	No	No	No	No	No	No	No	No	No	No	No	No	No	No	
Mann-Kendall Trend																						
	test statistic		-4	-44	-17	-17	-10	-3	-4	3	7	4	0	-45	-5	-37	5	-3	34	-33	-8	
	critical statistic		25	25	28	25	28	22	22	22	22	25	22	25	25	25	22	25	22	25	25	
	significant at %5 level?		No	**Yes**	No	No	No	No	No	No	No	No	No	**Yes**	No	**Yes**	No	No	**Yes**	**Yes**	No	
Sen's Slope Estimator	Slope (µg/L/yr)			-15.8										-7.74		-9.02			22.6	-9.00		

Notes:
* duplicate data averaged
Blank columns indicate that more than 50% of the values were non-detect for the analyte, and such, no meaningful trend information may be obtained.
Missing values in an otherwise populated column indicates that the corresponding value was identified as an outlier and removed from the trend analysis.
Sen's Slope was not calculated when the Mann-Kendall Trend test found no significant trend.

Table E. Seasonality and Trend Test Analysis, RW-6SR

Date	Sample ID	Quarter	2-Methylnaphthalene	Acenaphthene	Acenaphthylene	Anthracene	Benzo(a)anthracene	Benzo(a)pyrene	Benzo(b)fluoranthene	Benzo(g,h,i)perylene	Benzo(k)fluoranthene	Chrysene	Dibenz(a,h)anthracene	Dibenzofuran	Fluoranthene	Fluorene	Indeno(1,2,3-cd)pyrene	Naphthalene	Pentachlorophenol	Phenanthrene	Pyrene	Zinc
5/28/03	RW-6SR-0503	1		1.3	0.021	0.18	0.024	0.004047	0.004217		0.004809	0.03		0.18	0.23	0.44				0.5	0.28	
9/8/03	RW-6SR-O903	2		0.74	0.022	0.18	0.025	0.012	0.011		0.0094	0.03		0.14	0.29	0.25		1.3		0.4	0.25	
11/25/03	RW-6SR-1103	3	0.005673	0.44	0.018	0.14	0.026	0.0074	0.0069		0.0048	0.029		0.078	0.37	0.11		0.25		0.11	0.39	
2/25/04	RW-6SR-0204	4	0.019	1.1	0.019	0.15	0.018	0.0039	0.0083		0.0072	0.023		0.23	0.22	0.35		1.2		0.1	0.27	
5/20/04	RW-6SR-0504	1	0.018	0.97	0.02	0.27	0.012	0.0017	0.0026		0.0017	0.011		0.26	0.15	0.28		1.9		0.039	0.16	
8/17/04	RW-6SR-0804	2	0.004711	0.67	0.02	0.18	0.014795	0.003453	0.002615		0.004465	0.014521		0.15	0.15	0.16		0.57		0.006878	0.19	
11/22/04	RW-6SR-1104	3	0.0069	0.46	0.013	0.14	0.014					0.011		0.088	0.24	0.12		0.56		0.011	0.26	
2/23/05	RW-6SR-0205*	4	0	0.165	0.0155	0.24	0.0145	0.0038	0.0053		0.0045	0.0145		0.00855	0.135	0		0.0455		0.006878	0.185	
5/26/05	RW-6SR-0505	1	0.0074	0.014	0.012	0.17	0.016	0.008	0.011		0.008	0.013		0.0138	0.049	0		0.033		0.001646	0.087	
8/26/05	RW-6SR-0805	2	0.0068	0.0086	0.016	0.19	0.015	0.0042	0.0065		0.0057	0.014		0	0.06	0		0		0.004266	0.23	
12/8/05	RW-6SR-1205	3		0.33	0.017	0.15	0.015					0.015		0.14	0.1	0.12				0.11	0.25	
2/28/06	RW-6SR-0206	4	0.0062	0.039	0.026	0.21	0.013	0.003453	0.004217		0.00191	0.011		0.036702	0.092	0.006		0.066		0.006878	0.091	
9/9/08	0908PSR01	2	0.01	0.030	0.01	0.01	0.012	0.004047	0.006573		0.005114	0.013		0.016	0.015	0.013		0.61		0.014	0.23	

		2-Methylnaphthalene	Acenaphthene	Acenaphthylene	Anthracene	Benzo(a)anthracene	Benzo(a)pyrene	Benzo(b)fluoranthene	Benzo(g,h,i)perylene	Benzo(k)fluoranthene	Chrysene	Dibenz(a,h)anthracene	Dibenzofuran	Fluoranthene	Fluorene	Indeno(1,2,3-cd)pyrene	Naphthalene	Pentachlorophenol	Phenanthrene	Pyrene	Zinc
Kruskal-Wallis Seasonality																					
	test statistic	1.75	0.96	0.96	4.72	0.49	2.49	0.7		0.96	0.35		1.22	1.88	0.82		0.3		1.33	3.36	
	critical statistic	7.81	7.81	7.81	7.81	7.81	7.81	7.81		7.81	7.81		7.81	7.81	7.81		7.81		7.81	7.81	
	significant at %5 level?	No	No	No	No	No	No	No		No	No		No	No	No		No		No	No	
Mann-Kendall Trend																					
	test statistic	-3	-52	-27	-5	-36	-9	-1		-7	-39		-33	-53	-40		-23		-40	-30	
	critical statistic	19	25	28	28	28	22	22		22	28		28	25	28		22		28	25	
	significant at %5 level?	No	**Yes**	No	No	**Yes**	No	No		No	**Yes**		**Yes**	**Yes**	**Yes**		**Yes**		**Yes**	**Yes**	
Sen's Slope Estimator	Slope (µg/L/yr)		-0.372			-0.00168					-0.00345		-0.0471	-0.0708	-0.100		-0.498793		-0.0455	-0.0266	

Notes:
* duplicate data averaged
Blank columns indicate that more than 50% of the values were non-detect for the analyte, and such, no meaningful trend information may be obtained.
Missing values in an otherwise populated column indicates that the corresponding value was identified as an outlier and removed from the trend analysis.
Sen's Slope was not calculated when the Mann-Kendall Trend test found no significant trend.

Table E. Seasonality and Trend Test Analysis, RW-12S

Date	Sample ID	Quarter	2-Methylnaphthalene	Acenaphthene	Acenaphthylene	Anthracene	Benzo(a)anthracene	Benzo(a)pyrene	Benzo(b)fluoranthene	Benzo(g,h,i)perylene	Benzo(k)fluoranthene	Chrysene	Dibenz(a,h)anthracene	Dibenzofuran	Fluoranthene	Fluorene	Indeno(1,2,3-cd)pyrene	Naphthalene	Pentachlorophenol	Phenanthrene	Pyrene	Zinc
5/28/03	RW-12S-0503	1	0.100	0.630	0.050	0.160	0.061	0.005	0.021		0.00659	0.07		0.028	0.86	0.230		4.6		0.067	0.79	
9/9/03	RW-12S-0903	2	0.180	0.970	0.100	0.430	0.080	0.005	0.018		0.014	0.081		0.057	1.40	0.360		7.5		0.11	0.96	
11/24/03	RW-12S-1103	3	0.000	0.290	0.012	0.120	0.060	0.004	0.010		0.0044	0.055		0.014	0.77	0.110		0.52		0.016	0.65	
2/25/04	RW-12S-0204	4	0.016	0.600	0.018	0.210	0.068	0.006	0.016		0.011	0.068		0.018	1.10	0.230		0.79		0.043	1.00	
5/20/04	RW-12S0504	1	0.110	0.910	0.080	0.750	0.081	0.013	0.015		0.013	0.07		0.041	1.30	0.350		4.7		0.1	1.00	
8/17/04	RW-12S-0804	2	0.120	1.100	0.082	0.560	0.089	0.009	0.013		0.009012	0.068069		0.051	1.50	0.430		4.9		0.11	1.00	
11/23/04	RW-12S-1104	3	0.042	0.790	0.055	0.410	0.072	0.006	0.015		0.008057	0.042		0.026	1.50	0.240		2.4		0.073	1.20	
2/24/05	RW-12S-0205	4	0.022	0.700	0.034	0.380	0.071	0.005	0.015		0.0061	0.072		0.019	1.20	0.220		1.6		0.023299	0.96	
5/27/05	RW-2S-0505*	1	0.022	0.600	0.032	0.290	0.070	0.009	0.017		0.0125	0.069		0.0135	1.15	0.180		1.5		0.023	0.81	
8/25/05	RW-12S-0805	2	0.084	0.880	0.066	0.560	0.087	0.010	0.016		0.006289	0.083		0.041	2.00	0.380		4.3		0.12	1.50	
12/8/05	RW-12S-1205	3	0.290	1.000	0.047	0.340	0.091	0.017	0.039		0.011489	0.089		0.15	1.20	0.330		11		0.15	1.10	
2/28/06	MW-12S-0206	4	0.009	0.400	0.017	0.260	0.080	0.009	0.016		0.013	0.069		0.0081	1.00	0.150		0.21		0.024	0.73	
9/11/08	0908PSR15	2	0.034	0.340	0.017	0.300								0.094	1.70	0.2000		0		0.16	1.80	
Kruskal-Wallis Seasonality																						
		test statistic	4.39	1.75	3.63	3.17	3.02	0.94	1.00		1.25	1.43		5.97	6.75	3.29		2.33		6.08	3.34	
		critical statistic	7.81	7.81	7.81	7.81	7.81	7.81	7.81		7.81	7.81		7.81	7.81	7.81		7.81		7.81	7.81	
		significant at %5 level?	No	No	No	No	No	No	No		No	No		No	No	No		No		No	No	
Mann-Kendall Trend																						
		test statistic	-5	-9	-21	1	25	28	6		5	14		3	20	-11		-18		19	26	
		critical statistic	28	25	28	25	25	25	25		25	25		28	25	25		28		28	25	
		significant at %5 level?	No	No	No	No	**Yes**	**Yes**	No		No	No		No	No	No		No		No	**Yes**	
Sen's Slope Estimator		Slope (µg/L/yr)					0.00630	0.002235													0.122	

Notes:
* duplicate data averaged
Blank columns indicate that more than 50% of the values were non-detect for the analyte, and such, no meaningful trend information may be obtained.
Missing values in an otherwise populated column indicates that the corresponding value was identified as an outlier and removed from the trend analysis.
Sen's Slope was not calculated when the Mann-Kendall Trend test found no significant trend.

Table E. Seasonality and Trend Test Analysis, MW-14S

Date	Sample ID	Quarter	2-Methylnaphthalene	Acenaphthene	Acenaphthylene	Anthracene	Benzo(a)anthracene	Benzo(a)pyrene	Benzo(b)fluoranthene	Benzo(g,h,i)perylene	Benzo(k)fluoranthene	Chrysene	Dibenz(a,h)anthracene	Dibenzofuran	Fluoranthene	Fluorene	Indeno(1,2,3-cd)pyrene	Naphthalene	Pentachlorophenol	Phenanthrene	Pyrene	Zinc
05/23/03	MW-14S-0503	1	350	290	9.2	23	0.9	0.21	0.28	0.031	0.24	0.85		160	13	130	0.057	4300	3200	100	8.3	12.5
09/08/03	MW-14S-0903	2	590	290	7.3	4.3	0.22	0.19	0.063	0.2	0.033	0.19		170	8.2	93	0.032	9000	42	120	3.4	0
11/26/03	MVvM 41-1 103	3	390	440	11	30	0.92	0.23	0.27	0.052	0.19	0.73		240	16	200	0.077	5900	2500	140	9.8	19.4
02/25/04	MW-14S-0204*	4	315	395	8.3	21	0.61	0.195	0.27	0.12	0.205	0.635		160	12	160	0.135	5200	2650	130	7.95	22.55
05/20/04	MW-14S-0504	1	280	330	9.3	22	0.44	0.11	0.16	0.053	0.14	0.43		200	12	150	0.074	5000	2200	93	6.2	75.1
08/17/04	MW-14S-0804	2	160	180	8.5	24	0.32	0.071	0.086	0.051103	0.072	0.4		110	10	87	0.023	2900	1400	64	5.4	24.9
11/22/04	MW-14S-1104*	3	225	435	9.1	15.5	0.77	0.150014	0.1819	0.068349	0.1363	0.55		220	11	155	0.07625	6100	1500	115	6	31.65
02/23/05	MW-14S-0205	4	340	390	9.5	23	0.43	0.059	0.11	0.068349	0.068	0.45		240	13	190	0.07625	6100	1500	150	6.7	25.9
05/26/05	MW-14S-0505	1	200	300	8.3	17	0.33	0.150014	0.1819	0.068349	0.1363	0.3		170	9.2	150	0.07625	5400	560	110	4.8	68.4
08/25/05	MW-14S-0805	2	290	370	11	20	0.35	0.150014	0.1819	0.068349	0.1363	0.29		210	10	170	0.07625	5600	410	120	5.5	0
12/07/05	MW-14S-1205	3	220	370	8.8	12	0.87	0.123699	0.16	0.049	0.1	0.53		180	12	140	0.07625	4400	26	130	6.5	0
02/27/06	MW-14S-0206	4	190	340	8.5	16	0.49	0.13	0.15	0.06	0.11	0.43		210	12	160	0.077	4800		130	5.6	0
09/09/08	0908PSR05	2	69	380	9.01									190		150		3,200		160		
Kruskall-Wallis Seasonality		test statistic	0.4	6.77	1.02	0.48	7.41	0.75	3.47	2.71	3.87	6.14		3.28	5.18	4.46	6.79	1.09	3.7	5.39	5	3.1
		critical statistic	7.81	7.81	7.81	7.81	7.81	7.81	7.81	7.81	7.81	7.81		7.81	7.81	7.81	7.81	7.81	7.81	7.81	7.81	7.81
		significant at %5 level?	No	No	No	No	No	No	No	No	No	No		No	No	No	No	No	No	No	No	No
Mann-Kendall Trend		test statistic	-48	6	3	-19	-6	-27	-15	-2	-21	-21		14	-8	6	17	-21	-32	24	-16	-8
		critical statistic	25	25	28	25	25	25	25	25	25	25		25	25	25	25	25	22	25	25	25
		significant at %5 level?	**Yes**	No	No	No	No	**Yes**	No	No	No	No		No	No	No	No	No	**Yes**	No	No	No
Sen's Slope Estimator		Slope (µg/L/yr)	-51.1					-0.029829											-1.29E+03			

Notes:
* duplicate data averaged
Blank columns indicate that more than 50% of the values were non-detect for the analyte, and such, no meaningful trend information may be obtained.
Missing values in an otherwise populated column indicates that the corresponding value was identified as an outlier and removed from the trend analysis.
Sen's Slope was not calculated when the Mann-Kendall Trend test found no significant trend.

Table E. Seasonality and Trend Test Analysis, RW-1S

Date	Sample ID	Quarter	2-Methylnaphthalene	Acenaphthene	Acenaphthylene	Anthracene	Benzo(a)anthracene	Benzo(a)pyrene	Benzo(b)fluoranthene	Benzo(g,h,i)perylene	Benzo(k)fluoranthene	Chrysene	Dibenz(a,h)anthracene	Dibenzofuran	Fluoranthene	Fluorene	Indeno(1,2,3-cd)pyrene	Naphthalene	Pentachlorophenol	Phenanthrene	Pyrene	Zinc
05/23/03	RW-1S-0503	1	11	270	6.1	8	0.5	0.16	0.23	0.065	0.15	0.3	0.019	86	14	93	0.1	1100	430	52	7.2	2
09/08/03	RW-1S-0903	2	5.7	370	4.6	14	0.88	0.49	0.39	0.24	0.5	0.71	0.095	180	20	170	0.3	1200	220	140	9.7	12.6
11/25/03	RW-1S-1103	3	3.6	360	8.8	14	1.2	0.5	0.53	0.19	0.39	0.81	0.048	130	24	130	0.27	810	93	63	15	8.7
02/26/04	RW-1S-0204	4	0.59	290	6.4	9.2	1.2	0.55	0.62	0.44	0.48	1	0.1	100	21	130	0.51	180	22	48	13	3.2
05/20/04	RW-1S-0504*	1	6.35	290	6.1	9.2	0.445	0.145	0.185	0.051	0	0.305	0.2	83	18	78	0.077	705	235	34	9	1.82
08/17/04	RW-1S-0804	2	5.1	180	6.4	13	0.96	0.94	1	0.64	0.46	0.78	0.12	92	22	85	0.82	510	31	59	12	4
11/23/04	RW-1S-1104	3	1.4	480	6.8	14	0.92	0.63	0.7	0.56	0.2	0.72	0.12	140	22	140	0.48	660	4	65	11	13.8
02/24/05	RW-1S-0205	4	1.2	370	4.8	11	0.54	0.13	0.18	0.039	0.11	0.42	0.097	170	23	160	0.051	870	1.3	90	12	2.2
05/27/05	RW-1S-0505	1	0.37	310	2.7	11	1.1	1.3	2.1	0.85	0.039	0.84	0.077	150	21	140	1.2	380	2.3	89	12	12.9
08/26/05	RW-1S-0805	2	0.89	380	4.7	11	0.47	0.32	0.3	0.24	0.11	0.28	0.04	160	17	160	0.26	710	17	110	9.2	1.40
12/07/05	RW-1S-1205	3	0.48	350	5.7	11	0.72	1.1	1.2	0.78	0.26	0.59	0.13	140	22	140	0.91	670	2.9	89	11	5.77
02/28/06	MW-1S-0206	4	0.4	260	7.4	10	0.68	0.86	0.84	0.93	0.21	0.51	0.12	110	15	110	1	57	13	55	7.8	18.7
09/09/08	0908PSR07	2	1.59	360	4.26	12								150	29	170		86	7	160	17	0.02
Kruskal-Wallis Seasonality		test statistic	3.01	3.11	4.51	7.86	1.79	1.1	1.1	0.49	4.75	1.05	0.96	2.79	3.93	3.36	0.33	1.09	2.2	4.94	1.96	2.86
		critical statistic	7.81	7.81	7.81	7.81	7.81	7.81	7.81	7.81	7.81	7.81	7.81	7.81	7.81	7.81	7.81	7.81	7.81	7.81	7.81	7.81
		significant at %5 level?	No	No	No	Yes	No	No	No	No	No	No	No	No	No	No	No	No	No	No	No	No
Mann-Kendall Trend		test statistic	-42	5	-14	n/a	-9	22	22	29	-28	-6	15	16	12	20	22	-36	-42	25	4	-2
		critical statistic	28	25	28	25	25	25	25	25	25	25	25	25	25	25	25	25	28	25	25	28
		significant at %5 level?	**Yes**	No	No	n/a	No	No	No	**Yes**	**Yes**	No	No	No	No	No	No	**Yes**	**Yes**	**Yes**	No	No
Sen's Slope Estimator		Slope (µg/L/yr)	-1.54							0.289	-0.117							-173	-42.6	21.6		

Notes:
* duplicate data averaged
Blank columns indicate that more than 50% of the values were non-detect for the analyte, and such, no meaningful trend information may be obtained.
Missing values in an otherwise populated column indicates that the corresponding value was identified as an outlier and removed from the trend analysis.
Sen's Slope was not calculated when the Mann-Kendall Trend test found no significant trend.

Table E. Seasonality and Trend Test Analysis, MW-3I

Date	Sample ID	Quarter	2-Methylnaphthalene	Acenaphthene	Acenaphthylene	Anthracene	Benzo(a)anthracene	Benzo(a)pyrene	Benzo(b)fluoranthene	Benzo(g,h,i)perylene	Benzo(k)fluoranthene	Chrysene	Dibenz(a,h)anthracene	Dibenzofuran	Fluoranthene	Fluorene	Indeno(1,2,3-cd)pyrene	Naphthalene	Pentachlorophenol	Phenanthrene	Pyrene	Zinc
05/23/03	MW-31-0503	1	0.0260	0.0160	0.0200	0.0160	0.0110	0.0025	0.0060	0.0038	0.0021	0.0120		0.0132	0.0520	0.0190	0.0028	0.0290		0.0460	0.0490	18.1
09/08/03	MW-3I-0903	2	0.0160	0.0540	0.0760	0.1000	0.0110	0.0027	0.0053	0.0044	0.0018	0.0140		0.0130	0.0820	0.0220		0.0730		0.0470	0.0830	4.6
11/25/03	MW-31-1103	3	0.0095	0.0340	0.1000	0.1000	0.0170	0.0059	0.0080	0.0061	0.0057	0.0160		0.0100	0.0720	0.0240	0.0040	0.0630		0.0560	0.1100	12.1
02/26/04	MW-3I-0204	4	0.0340	0.0260	0.0072	0.0350	0.0160	0.0031	0.0068	0.0059	0.0034	0.0170		0.0120	0.1200	0.0370		0.0780		0.1700	0.1300	12.9
05/20/04	MW-3I-0504	1	0.0160	0.0300	0.0170	0.0800	0.0190	0.0057	0.0100	0.0059	0.0065	0.0170		0.0160		0.0390	0.0026	0.0450		0.1200	0.0800	5.8
08/17/04	MW-3I-0804	2	0.0210	0.0620	0.0640	0.1600	0.0190	0.0050	0.0073	0.0034	0.0048	0.0155		0.0390	0.0590	0.0540	0.0035	0.0615		0.0950	0.0860	5.0
11/22/04	MW-31-1104	3	0.0089	0.0300	0.0510	0.1500	0.0170	0.0059	0.0096	0.0060	0.0053	0.0120		0.0079	0.0510	0.0190	0.0090	0.0580		0.0410	0.0760	1.6
02/23/05	MW-3I-0205	4	0.0082	0.0360	0.0590	0.3100	0.0210	0.0130	0.0170	0.0097	0.0130	0.0250		0.0140	0.1000	0.0350	0.0084	0.0540		0.0530	0.1500	8.0
05/26/05	MW-3I-0505	1	0.0190	0.0730	0.0460	0.1300	0.0160	0.0093	0.0140	0.0071	0.0060	0.0180		0.0160	0.0490	0.0300	0.0085	0.1200		0.0460	0.0550	11.4
08/26/05	MW-3I-0805	2	0.0110	0.0460	0.0850	0.1900	0.0170	0.0065	0.0140	0.0074	0.0037	0.0160		0.0110	0.0650	0.0200	0.0026	0.1100		0.0460	0.1000	8.8
12/07/05	MW-31-1205	3			0.0490	0.1400	0.0190	0.0059	0.0096	0.0055	0.0068	0.0120			0.0630		0.0060	0.1500		0.1400	0.0930	
02/27/06	MW-3I-0206	4	0.0100	0.0370	0.0500	0.1800	0.0160	0.0057	0.0083	0.0054	0.0050	0.0170		0.0160	0.0830	0.0360	0.0050			0.0620	0.1000	0.1
09/09/08	0908PSR04	2			0.0482	0.0379									0.0664	0.0305				0.0724	0.0755	
Kruskall-Wallis Seasonality		test statistic	3.84	3.49	5.96	2.49	1.01	0.97	0.58	0.94	3.51	5.65		5.02	8.31	3.1	3.59	1.29		1.19	7.93	1.65
		critical statistic	7.81	7.81	7.81	7.81	7.81	7.81	7.81	7.81	7.81	7.81		7.81	7.81	7.81	7.81	7.81		7.81	7.81	7.81
		significant at %5 level?	No	No	No	No	No	No	No	No	No	No		No	Yes	No	No	No		No	Yes	No
Mann-Kendall Trend		test statistic	-18	20	-2	27	6	28	30	15	24	13		-3	0	11	8	21		7	3	-17
		critical statistic	22	22	28	28	25	25	25	25	25	25		22	25	25	19	22		28	28	22
		significant at %5 level?	No	No	No	No	No	**Yes**	**Yes**	No	No	No		No	n/a	No	No	No		No	n/a	No
Sen's Slope Estimator		Slope (µg/L/yr)						0.001409	0.00191													

Notes:
* duplicate data averaged
Blank columns indicate that more than 50% of the values were non-detect for the analyte, and such, no meaningful trend information may be obtained.
Missing values in an otherwise populated column indicates that the corresponding value was identified as an outlier and removed from the trend analysis.
Sen's Slope was not calculated when the Mann-Kendall Trend test found no significant trend.

Table E. Seasonality and Trend Test Analysis. MW-11IR

Date	Sample ID	Quarter	2-Methylnaphthalene	Acenaphthene	Acenaphthylene	Anthracene	Benzo(a)anthracene	Benzo(a)pyrene	Benzo(b)fluoranthene	Benzo(g,h,i)perylene	Benzo(k)fluoranthene	Chrysene	Dibenz(a,h)anthracene	Dibenzofuran	Fluoranthene	Fluorene	Indeno(1,2,3-cd)pyrene	Naphthalene	Pentachlorophenol	Phenanthrene	Pyrene	Zinc
09/09/03	MW-11IR-0903	2	0.19	80		5.3	1.1	0.2	0.25	0.037	0.25			44	23	60	0.056	0.059		22	14	
11/25/03	MW-11IR-1103	3	0.69	57	1.3	0.88	0.63	0.1	0.14	0.027	0.11	0.44		33	14	29	0.035			1.7	7.4	
02/25/04	MW-11IR-0204	4		87	1	2.6	0.65	0.052	0.1	0.0087	0.088	0.41		44	21	61	0.011			100	14	
05/19/04	MW-11IR-0504	1	0.005603	0.48	0.051	0.26	0.22	0.083	0.12	0.013	0.13	0.28		0	2.3	0.031	0.016	0.0210		0.044	0.52	
08/16/04	MW-11IR-0804	2	0.37	39	0.67	4.6								25	14	28		17		44	10	
11/23/04	MW-11IR-1104	3	0.053	49	0.38	1.9	0.41	0.034	0.068	0.0085	0.019	0.12		28	15	29	0.0034	0.44		74	8.3	
02/23/05	MW-11IR-0205	4	0.047	34	0.36	1.5	0.44	0.078	0.15	0.015	0.086	0.3		22	14	2	0.022	1.5		46	8	
05/27/05	MW-11IR-0505	1	0.056	34	0.31	3	0.59	0.025	0.043	0.00598	0.038	0.3		23	17	7.4	0.0146	0.77		55	11	
08/26/05	MW-11IR-0805*	2	0.035	21.5	0.205	2.3	0.595	0.036	0.0565	0.0042	0.048	0.305		16	15	0.96	0.005	0.54		38	9	
12/8/05	MW-11IR-1205	3	0.12	8.7	0.094	1.7	0.53	0.031	0.043	0.013759	0.045	0.26		8.7	15	0.24	0.0038	3.9		5.9	8.5	
02/27/06	MW-11IR-0206	4	0.027	5.1	0.31	1.4	0.85	0.12	0.16	0.022	0.13	0.4		2.3	15	0.16	0.031	1.8		0.48	7.1	
09/10/08	0908PSR11	1	0.72	0.48	0.2	0	0.64	0.053	0.099		0.081	0.36		0	12	0.24		14		0.28	7.3	
Kruskall-Wallis Seasonality		test statistic	2.24	3.52	3.14	4.85	2.86	1.65	2.91	1.18	2.19	1.54		3.32	1.82	2.41	1.18	0.31		1.67	3.05	
		critical statistic	7.81	7.81	7.81	7.81	7.81	7.81	7.81	7.81	7.81	7.81		7.81	7.81	7.81	7.81	7.81		7.81	7.81	
		significant at %5 level?	No	No	No	No	No	No	No	No	No	No		No	No	No	No	No		No	No	
Mann-Kendall Trend		test statistic	-5	-44	-32	-22	3	-17	-18	-13	-16	-2		-44	-9	-38	-15	21		-16	-19	
		critical statistic	22	22	22	25	22	22	22	19	22	17		25	25	22	19	19		22	22	
		significant at %5 level?	No	**Yes**	**Yes**	No	No	No	No	No	No	No		**Yes**	No	**Yes**	No	**Yes**		No	No	
Sen's Slope Estimator		Slope (µg/L/yr)		-22.1	-0.231									-9.86		-14.1		0.987				

Notes:
* duplicate data averaged
Blank columns indicate that more than 50% of the values were non-detect for the analyte, and such, no meaningful trend information may be obtained.
Missing values in an otherwise populated column indicates that the corresponding value was identified as an outlier and removed from the trend analysis.
Sen's Slope was not calculated when the Mann-Kendall Trend test found no significant trend.

Table E. Seasonality and Trend Test Analysis (continued). MW-15IR

Date	Sample ID	Quarter	2-Methylnaphthalene	Acenaphthene	Acenaphthylene	Anthracene	Benzo(a)anthracene	Benzo(a)pyrene	Benzo(b)fluoranthene	Benzo(g,h,i)perylene	Benzo(k)fluoranthene	Chrysene	Dibenz(a,h)anthracene	Dibenzofuran	Fluoranthene	Fluorene	Indeno(1,2,3-cd)pyrene	Naphthalene	Pentachlorophenol	Phenanthrene	Pyrene	Zinc
05/24/03	MW-15-IR-0503	1	0.063	4.4	0.12	0.21	0.3	0.0380	0.0810	0.0099	0.0530	0.3400	0.0021	2.1	3.8	1.7	0.009396	0.053		0.17	2	
09/09/03	MW-15IR-0903	2	230	230	2.6	8.2	0.2	0.0350	0.0550	0.0276	0.0510	0.2100	0.0095	160	8.2	130	0.024	4,000		98	3.7	
11/24/03	MW-15IR-1103	3	180	190	2.9	6.8	0.15	0.0180	0.0200	0.0047	0.0150	0.1200	0.0083	98	6.1	97	0.009396	3,600		69	3.5	
02/25/04	MW-15IR-0204	4	370	320	3.7	11	0.5	0.2000	0.2200	0.1600	0.2000	0.4300	0.1500	130	14	150	0.15	5,000		130	7.7	
05/19/04	MW-15IR-0504	1	190	180	2.4	7.9	0.31	0.0440	0.0600	0.0341	0.0560	0.2500	0.0198	72	8.9	74	0.044619	2,900		65	4.2	
08/16/04	MW-15IR-0804	2	98	60	1.5	5.2	0.38	0.1100	0.1200	0.0370	0.1100	0.3600	0.0170	37	5.2	32	0.043	2,100		27	2.7	
11/23/04	MW-15IR-1104	3	160	220	3.9	6.9	1	0.1010	0.1366		0.1129	0.6600	0.0237	110	10	99	0.062985	4,500		89	6	
02/24/05	MW-15IR-0205	4	300	240	2.8	8.8	0.78	0.1600	0.2200	0.0360	0.2000	0.6700	0.0098	130	12	120	0.048	5,700		100	6.4	
05/27/05	MW-15IR-0505	1	110	91	2.2	7		1.1000	1.5000	0.2500	1.3000		0.0790	54	26	52	0.32	3800		80	15	
08/26/05	MW-15IR-0805	2	98	130	1.7	4.3	1	0.2900	0.3800	0.0670	0.2900	0.9200	0.0250	57	8.4	60	0.11	3200		50	5.2	
12/08/05	MW-15IR-1205	3	230	280	2.9	8.4	1.6	0.4500	0.6200	0.0900	0.4100	1.4000	0.0310	130	18	130	0.11	4,600		110	11	
02/28/06	MW-15IR-0206	4	92	250	2.7	10		2.0000	2.5000	0.4500	2.2000		0.3400	85	53	120	0.67	1,400		120	27	
09/10/08	0908PSR12	2	300	350										190		210		4,600				
Kruskall-Wallis Seasonality		test statistic	1.81	5.58	8.67	6.59	1.46	1.97	1.98	2.14	1.98	1.45	1.97	4.26	4.23	4.77	2.54	3.06		7.1	3.92	
		critical statistic	7.81	7.81	7.81	7.81	7.81	7.81	7.81	7.81	7.81	7.81	7.81	7.81	7.81	7.81	7.81	7.81		7.81	7.81	
		significant at %5 level?	No	No	Yes	No	No	No	No	No	No	No	No	No	No	No	No	No		No	No	
Mann-Kendall Trend		test statistic	-1	26	5	14	32	46	47	35	49	33	38	13	38	20	42	11		18	40	
		critical statistic	25	25	25	25	19	25	25	22	25	19	25	25	25	25	25	25		25	25	
		significant at %5 level?	No	**Yes**	n/a	No	**Yes**	**Yes**	**Yes**	**Yes**	**Yes**	**Yes**	**Yes**	No	**Yes**	No	**Yes**	No		No	**Yes**	
Sen's Slope Estimator		Slope (µg/L/yr)		26.5			0.503	0.212	0.253	0.038	0.188	0.439	0.0111		4.67		0.0511				3.25	

Notes:
* duplicate data averaged
Blank columns indicate that more than 50% of the values were non-detect for the analyte, and such, no meaningful trend information may be obtained.
Missing values in an otherwise populated column indicates that the corresponding value was identified as an outlier and removed from the trend analysis.
Sen's Slope was not calculated when the Mann-Kendall Trend test found no significant trend.

Table E. Seasonality and Trend Test Analysis (continued). MW-14I

Date	Sample ID	Quarter	2-Methylnaphthalene	Acenaphthene	Acenaphthylene	Anthracene	Benzo(a)anthracene	Benzo(a)pyrene	Benzo(b)fluoranthene	Benzo(g,h,i)perylene	Benzo(k)fluoranthene	Chrysene	Dibenz(a,h)anthracene	Dibenzofuran	Fluoranthene	Fluorene	Indeno(1,2,3-cd)pyrene	Naphthalene	Pentachlorophenol	Phenanthrene	Pyrene	Zinc
05/02/03	MW-14I-0503	1	220	160	5.3	14	1	0.21	0.26	0.054	0.27	0.88	0.026	90	14	91	0.092	2,500	120	110	8	
09/08/03	MW-14I-0903*	2	355	375	9.35	15	1.05	0.35	0.44	0.099	0.325	1.1	0.038	215	15.5	165	0.16	6100		125	7.55	8.5
11/26/03	MW-14S-1103	3	500	230	5.2	5.5	0.24	0.058	0.082	0.084	0.048	0.18	0.052	130	5.1	73	0.035	7,800	23	85	2.4	30.9
02/25/04	MW-14I-0204	4	750	360	8.3	20	2	0.66	0.88	0.190	0.67	1.8	0.099	160	20	170	0.24	9,800	21	170	13	25.9
05/20/04	MW-14I-0504	1	500	230	5.7	17	0.17	0.036	0.042	0.117	0.028	0.12	0.052	53	9.8	66	0.105	7,400	9	84	3.5	0
08/17/04	MW-141-0804	2	190	110	4	5.8	0.38	0.29	0.14	0.037	0.12	0.32	0.017	66	6.4	50	0.048	3,700	1.7	46	3.4	5.1
11/22/04	MW-141-1104	3	470	380	9.4	22	10	3.8	6.6	1.1	2.4	9.4	0.590	290	60	160	1.3	8,600	6.4	280	38	70.7
02/23/05	MW-141-0205	4	76	390	6.9	27	19	7.5	10	2.1	7.3	16	0.820	230	110	170	2.7	11,000	9.9	330	75	4.7
05/27/05	MW-141-0505	1	500	550	13	78	60	24	30	6.6	23	54	2.9	370	370	460	7.4	7,300	2.4	890	260	36
08/25/05	MW-141-0805	2	510	590	13	49	48	17	24	4.5	16	45	2	350	280	280	5.5	6,700	8.88	820	190	17.1
12/07/05	MW-141-12-5	3	700	810	17	62	74	26	30	6.8	34	69	2.4	480	440	430	9.2	8,400	5.09	1200	270	0
02/27/05	MW-141-0206	4	860	780	20	52	81	30	40	7.4	27	66	4.6	470	410	380	10	9,200	15.14	1200	240	
09/09/08	0908PSR06	2	1,600														0.591	15000	23			0
Kruskall-Wallis Seasonality		test statistic	0.58	1.56	0.71	1.05	1.77	1.92	1.66	2.08	1.51	1.51	2.38	1.77	1.26	1.16	1.54	5.74	0.86	1.87	1.05	0.86
		critical statistic	7.81	7.81	7.81	7.81	7.81	7.81	7.81	7.81	7.81	7.81	7.81	7.81	7.81	7.81	7.81	7.81	7.81	7.81	7.81	7.81
		significant at %5 level?	No	No	No	No	No	No	No	No	No	No	No	No	No	No	No	No	No	No	No	No
Mann-Kendall Trend		test statistic	37	33	27	32	34	36	33	38	32	32	37	28	32	19	48	32	-13	41	40	-14
		critical statistic	25	25	25	25	25	25	25	25	25	25	25	25	25	25	28	25	25	25	25	22
		significant at %5 level?	**Yes**	**Yes**	**Yes**	**Yes**	**Yes**	**Yes**	**Yes**	**Yes**	**Yes**	**Yes**	**Yes**	**Yes**	**Yes**	No	**Yes**	**Yes**	No	**Yes**	**Yes**	No
Sen's Slope Estimator		Slope (µg/L/yr)	139	164	3.41	16.5	27.2	9.7	13.0	2.58	9.48	23.5	1.04	127	143		3.38	1.02E+03		446	117	

Notes:
* duplicate data averaged
Blank columns indicate that more than 50% of the values were non-detect for the analyte, and such, no meaningful trend information may be obtained.
Missing values in an otherwise populated column indicates that the corresponding value was identified as an outlier and removed from the trend analysis.
Sen's Slope was not calculated when the Mann-Kendall Trend test found no significant trend.

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Attachment 8

DNAPL Recovery Table with Boring Logs for MW-14I, MW-15IR Illustrating NAPL Thickness

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Attachment 8, DNAPL Recovery Table with Boring Logs for MW-14I, MW-15IR Illustrating NAPL Thickness

Table A8-1. DNAPL Recovery at PSR for 2007 and 2008

Removal Date	MW-5I			RW-1D			RW-1I			MW-13I			Totals (gal)	Total DNAPL Removed to Date (gal)
	Liquid removed (gal)	DNAPL Recovered (gal)	Total DNAPL Removed to Date (gal)	Liquid removed	DNAPL Recovered (gal)	Total DNAPL Removed to Date (gal)	Liquid removed	DNAPL Recovered (gal)	Total DNAPL Removed to Date (gal)	Liquid removed	DNAPL Recovered (gal)	Total DNAPL Removed to Date (gal)		
1/26/2007	2	0.56	74.06	2.5	0.4	1,023.85	1.25	0.18	76.43	5	3.618	47.52	4.758	1,348.01
2/23/2007	-	-	-	-	-	-	-	-	-	3.6	1.2	48.72	1.2	1,349.21
3/29/2007	2.5	0.83	74.89	3.25	0.81	1,024.66	2.4	0	76.43	3.25	1.49	50.21	3.13	1,352.34
6/11/2007	1.25	1	75.89	1.9	1	1,025.66	0.7	0.5	76.93	2.5	1.5	51.71	4	1,356.34
9/23/2007	1.5	1.4	77.29	4.5	0.75	1,026.41	1.25	0.5	77.43	4.25	2	53.71	4.65	1,360.99
10/22/2007	-	-	76.89	-	-	1,026.41	-	-	78.18	2.5	0.8	54.51	0.8	1,361.79
12/20/2007	1	0.5	77.39	3	1	1,027.41	1.5	0.5	78.68	2.5	1	56.01	3	1,364.79
3/19/2008	2.5	0.5	77.89	1.5	0.5	1,027.91	1.5	trace	78.68	3.2	0.5	56.51	1.5	1,366.29
6/11/2008	2.5	0.25	78.14	4.5	0.75	1,028.66	1.75	trace	78.68	3	1.5	58.01	3	1,369.29
10/8/2008	2.6	0.5*	78.64	2.4	0.75*	1,029.41	2.25	0.2*	78.88	2.75	1.75*	59.76	3.2*	1,372.49

Note

* - DNAPL recovery volume is an estimate. Recovery volume will be updated after next event.

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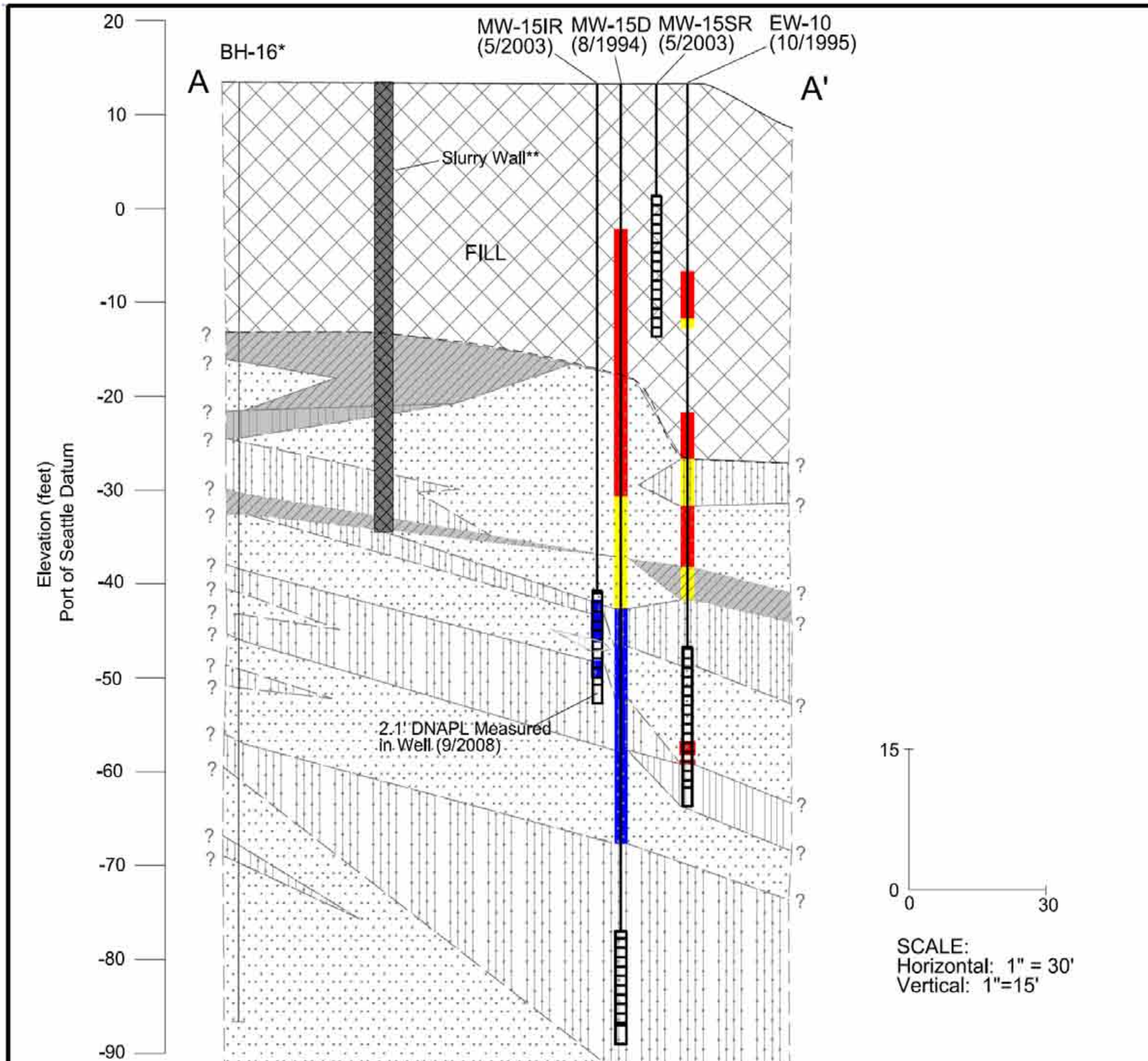

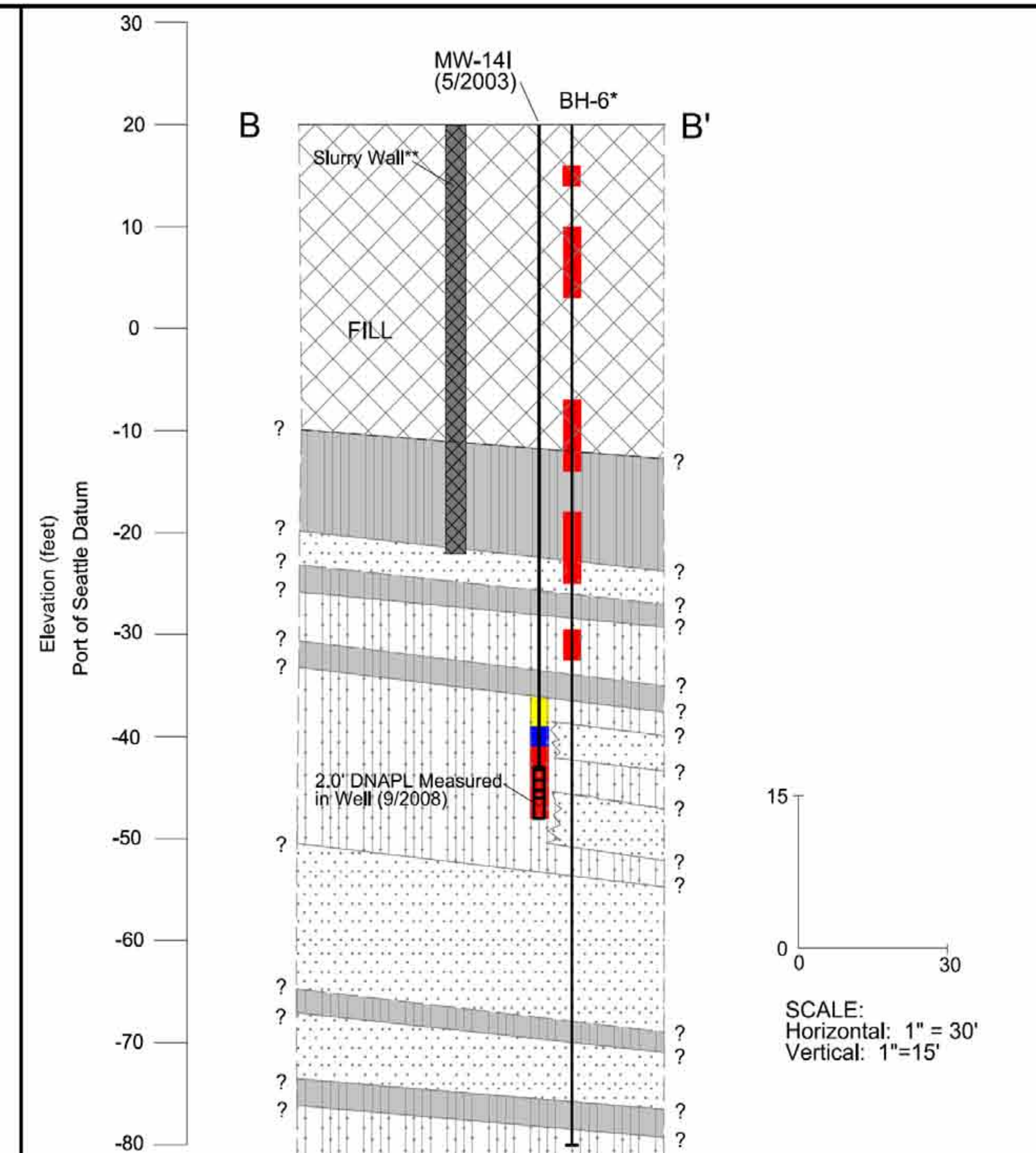

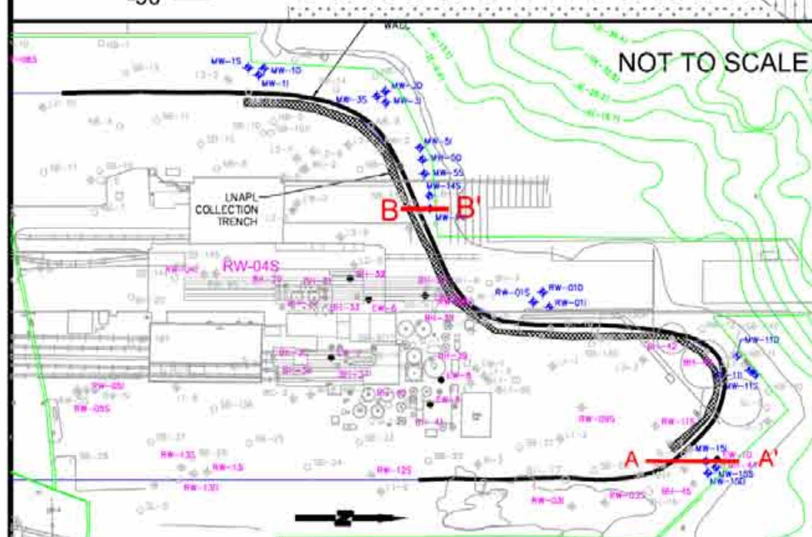

LEGEND:

MW-15IR (5/2003) Borehole ID and Installation Date

Fill - Sand, silty sand, or wood waste

Low Plasticity Clay (CL)

Silt to Sandy Silt (ML)

Silty Sand (SM)

Poorly Graded Sand (SP) Typically fine grained

Well Screen Interval

2' Sump

Borehole Observations during Installation:

Heavy sheen, strong odor

Slight sheen, slight odor

No sheen, slight odor

NOTES:

* Lithologic interpretation taken from cross-sections presented in the Basis of Design Report for Groundwater Containment, prepared by RETEC, and dated March 1995. Actual boreologs not available for review.

** Based on design depth in vicinity of MW-15 and MW-14 well series.

FIGURE 4

GEOLOGIC CROSS-SECTIONS A-A', B-B'

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Attachment 9

References

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Attachment 9, References

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